

EVALUATION OF NRC'S AQUATIC AND CROP RESOURCE DEVELOPMENT RESEARCH CENTRE

Office of Audit and Evaluation

April 11, 2022

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ACRONYMS

ACRD

Aquatic and Crop Resource Development

CRL

Client Relationship Leader

EDI

Equity, Diversity and Inclusion

FWCI

Filed Weighted Citation Impact

HQP

Highly Qualified Personnel

IRAP

Industrial Research Assistance Program

ITAs

Industrial Technology Advisors

KPI

Key Performance Indicator

LIMS

Library and Information Management Services

NRC

National Research Council of Canada

OAE

Office of Audit and Evaluation

OCRE

Ocean, Coastal and River Engineering research centre

OECD

Organization for Economic Co-operation and Development

OGD

Other government departments (Canadian federal)

PHAC

Public Health Agency of Canada

PIC

Protein Industries Canada (also known as Protein Industry Supercluster)

PRC

Peer-Review Committee

PDF

Post Doctoral Fellow

R&D

Research and Development

SFS

Sustainable Food System Initiative

SEC

Senior Executive Council

SMEs

Small and Medium Sized Enterprises

SOW

Statement of Work

TRL

Technology Readiness Level

VP

Vice President



INTRODUCTION • AQUATIC AND CROP RESOURCE DEVELOPMENT RESEARCH CENTRE

An evaluation of the Aquatic and Crop Resource Development (ACRD) Research Centre was conducted in 2021-22. It assessed the research centre's relevance and performance. This report provides an overview of the main findings and conclusions as well as recommendations.



INTRODUCTION

The evaluation of the National Research Council Canada's (NRC's) Aquatic and Crop Resource Development (ACRD) Research Centre focused on a six-year period (2015-16 to 2020-21). It was carried out in accordance with the NRC Departmental Evaluation Plan and the Treasury Board Secretariat *Policy on Results* (2016). The ACRD Research Centre was last evaluated in 2015-16 and covered a three-year period beginning the year the portfolio was created in 2012-13.

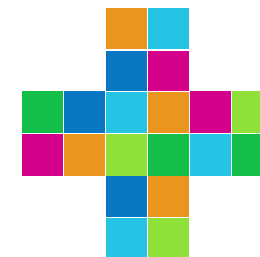
In this report, you will see the following symbols:



This symbol indicates information that is useful to know to help understand the findings



This symbol indicates a quote that helps illustrate or support the main findings.



This symbol indicates information that supports equity, diversity and inclusion, and Gender-Based Analysis+ (i.e., factors that illustrate how diverse groups may experience policies, programs and initiatives).



Sources: These are the methods from which the findings are drawn. The sources are listed at the bottom of each page.



EVALUATION APPROACH

Scope

In accordance with the NRC Departmental Evaluation Plan, an evaluation of the ACRD Research Centre was launched by the NRC Office of Audit and Evaluation (OAE) in October 2020. The evaluation focuses on the six-year period of 2015-16 to 2020-21.

Methods

The evaluation used a mixed method approach, incorporating both qualitative and quantitative methods. The lines of evidence used for this evaluation included a bibliometric analysis, document review, data review, external and internal interviews, client survey and an expert peer-review. The peer-review focused on the research centre's marine biotechnology activities and related areas of R&D. A gender-based and diversity lens has been applied throughout the evaluation.

See Appendix A for detailed information on the methodologies used for this evaluation, including limitations and mitigation strategies.

Questions

1. To what extent has the ACRD Research Centre contributed to longer-term outcomes, i.e.:
 - a. advancing scientific and technological knowledge?
 - b. business innovation?
 - c. evidence-based decision making in the government?
 - d. social and environmental sustainability?
2. To what extent does the ACRD Research Centre's current strategic plan position it to advance the sector and respond to the needs of the bioeconomy ecosystem (including the agrifood and marine biotechnology areas represented by their respective Supercluster stakeholder communities)? Is it focusing on the right areas?
3. Is the ACRD Research Centre engaging the right clients, collaborators and other stakeholders to achieve its objectives?
4. To what extent does the research centre have the capacities, competencies and facilities to achieve its objectives?
5. Has the geographic dispersion of the ACRD Research Centre (i.e., facilities, people) had any impact on the efficiency or effectiveness of the research centre? Are there efficiencies or performance improvements to be gained?



PROFILE • AQUATIC AND CROP RESOURCE DEVELOPMENT RESEARCH CENTRE

The ACRD Research Centre focuses on a range of R&D activities that enable the sustainable transformation of Canadian agriculture and marine bioresources into food and higher value products. The research centre currently has two core research strategic themes, namely, Agricultural Biotechnologies (with strategic R&D foci on plant-based proteins, northern agriculture, closed environments and climate change), and Marine Biotechnologies (with strategic R&D foci on ocean health, value-added products and sustainable aquaculture). These research themes are supported by an Industrial Biotechnology R&D Platform (with strategic R&D foci on lignocellulosic sugars, atypical fermentation).



OVERVIEW

The ACRD Research Centre was established in April 2012 through the consolidation of previous institutes at the NRC with different expertise, to build critical mass in biobased resource development. The research centre aims to make Canada a world leader in the sustainable transformation of biobased resources into economic value. The ACRD Research Centre provides scientific advice, and technical and strategic services to support the agrifood, marine biotechnology, sectors supported by an industrial biotechnology platform and currently has expertise in seven disciplines of importance to these sectors: Genomics and Plant Biotechnology, Marine Biotechnology, Natural Product Chemistry, Bioprocessing, Analytical Technologies, Algal Technologies and Zebrafish Technologies.

Mission and objectives (2018-19 to 2023-2024)

Vision: To make Canada a world leader in the sustainable transformation of bio-based resources into economic value.

Mission: To provide technical services, technology development support and credible scientific advice to help Canadian technology-based companies transform Canada's bio-based resources into sustainable, high-value products.

Current core research themes

Agricultural biotechnology

The ACRD Research Centre has a core platform of expertise and capabilities formed through a long history of supporting stakeholders in the agrifood sector. An emerging research focus is advancing scientific knowledge and technology development that promotes the development and sustainability of the Canadian food system. The ACRD Research Centre hosts the Sustainable Protein Production (SPP) Program in support of the Protein Industries Canada (PIC) Supercluster.

Marine biotechnology

Valorization of aquatic resources is a central pillar of the research centre. The ACRD Research Centre partners with stakeholders to sustainably develop marine bioproducts used in food, health, and personal care sectors, as well as support technologies that provide both environmental and economic benefits. The ACRD Research Centre leads the Bio Asset R&D thrust of the Oceans Supercluster Support Program and contributes to other initiatives that support Canada's Blue Economy Strategy.

Technology platform

Industrial biotechnology

Industrial biotechnology capabilities constitute a core platform, contributing across the spectrum of research centre supported programs and stakeholder engagement activities. Current strategic initiatives include a focus on valorizing lignocellulosic biomass to produce high-value chemicals, ingredients and products, and partnerships for enhancing ACRD expertise and capacity in atypical fermentation and bioprocessing.

Source(s): Document review



ACRD FINANCIAL PROFILE

Between 2015-16 and 2019-20, total NRC program investment to ACRD was approximately \$82M (data is not yet available for 2020-21). The program investment declined over the years, from \$20.2M in 2015-16 to \$11.1M in 2019-20, likely due to the ending of two ACRD flagship programs in 2018-19 (the Canadian Wheat Improvement program and the Algal Carbon Conversion program).

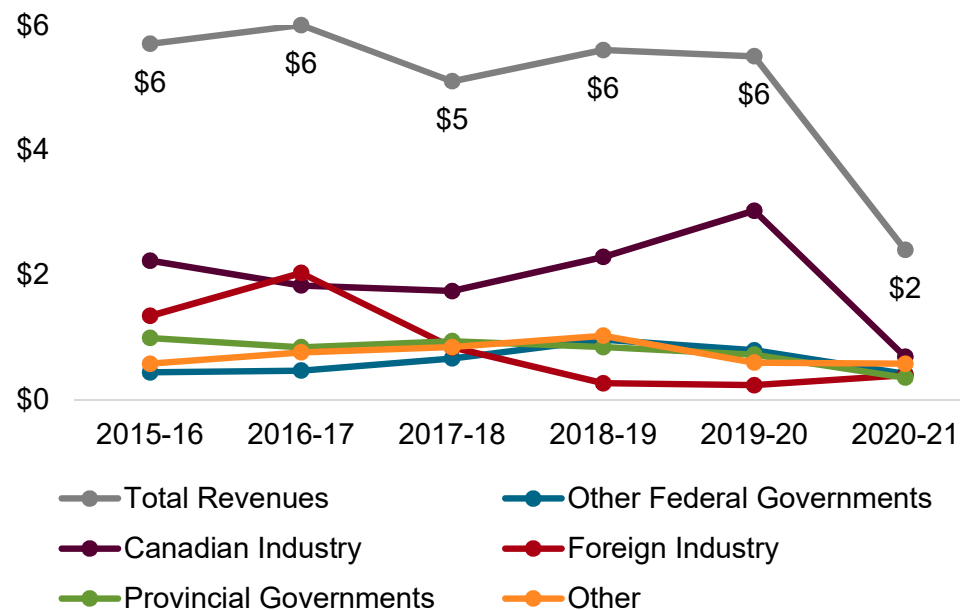
The ACRD Research Centre generated \$30.2M in revenues between 2015-16 and 2020-21. Technical R&D revenues accounted for 57% of the ACRD Research Centre's total revenue, while strategic R&D revenues accounted for 41%. The remainder came from "Other" sources (e.g., grants and contributions, lease and use of property). **Revenues remained stable over the evaluation period, except 2020-21 due to COVID-19 pandemic.**

The ACRD Research Centre expenses between 2015-16 and 2020-21 amounted to a total of \$207.3M. **Labour was the main source of direct expenditure (65%),** followed by use of NRC facilities, equipment and services (18%) and other operating costs (17%). Indirect expenses included research centre/branch expenses (74%), indirect facility expenses (24%) and indirect cost allocation (2%).

What is NRC Program Investment? NRC Program Investment includes NRC's planned investment of resources (people, equipment, facilities and out-of-pocket operating costs) to a program for a fiscal year.



Figure 1. Revenues (\$M) remained relatively stable, 2020-21 being an outlier due to COVID-19



Strategic vs. Technical services Research and Development (R&D) projects

Strategic R&D, or research services, consists of collaborative research projects undertaken with partners to de-risk R&D and accelerate commercial development timelines. Technical services consist of projects that solve immediate technical problems of clients through the delivery of specialized fee-for-service support (e.g., testing and certifications, calibration, prototyping, demonstrations, scale-up and consulting).



Source(s): Data review



HUMAN RESOURCES

As of January 2022, The ACRD Research Centre had a total of 205 staff including 104 technical officers (51%), 61 researchers (30%), 18 administrative staff (9%), 7 managers (3%) and 15 students (7%).

The ACRD Research Centre employees are spread across 6 locations* in Canada including Charlottetown, Halifax, Sandy Cove (SC/Ketch Harbour), Montreal, Ottawa, and Saskatoon. These locations are grouped in terms of geographic areas (i.e., West, Central and East).

Each of the geographic areas has unique expertise and a Director of R&D. In 2020-21, half (50%) of employees were located in Saskatoon, while 16% were in Halifax and 12% in Montreal. The remaining staff were located in Charlottetown, Sandy Cove, Ottawa or working remotely from other locations.

Figure 2.
ACRD's organizational structure



*The ACRD Research Centre employees in Boucherville, Victoria and Winnipeg are working under alternative work arrangements; The ACRD Research Centre does not maintain any facilities in these locations.

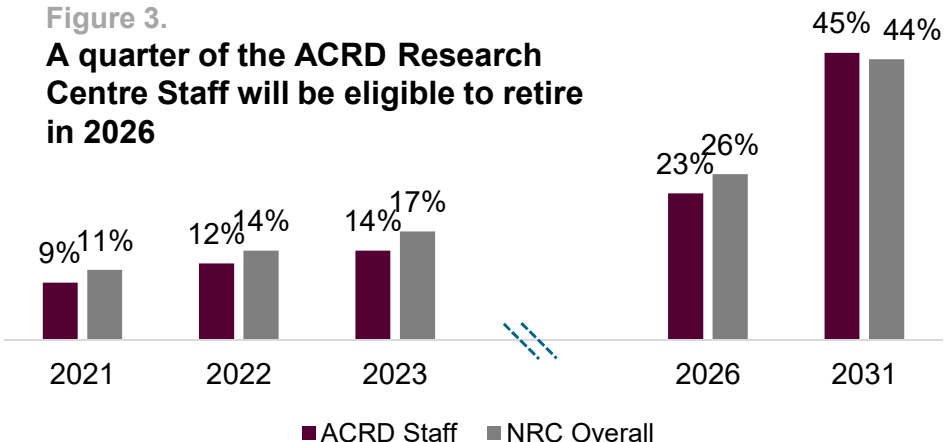
Source(s): Data review, document review



DEMOGRAPHIC PROFILE

In 2020-21, the largest proportion of staff were in the age group 46 and older (nearing the earliest possible retirement age of 55). By 2026, 23% of ACRD's workforce will be eligible to retire. This almost doubles in 2031. Among the researcher staff, research officers (ROs) will have the highest eligibility rate (25%) in 2026, followed by technical officers (TOs, 22%) and research council officers (RCOs, 13%).

Figure 3.
A quarter of the ACRD Research Centre Staff will be eligible to retire in 2026



Most ACRD Research Centre staff have university degrees (i.e., Doctorates, Master's, Bachelor's). More than a quarter of the ACRD Research Centre staff came from different fields of biology, including microbiology, plant biotechnology, genetics, general microbiology, biotechnology, cell biology, physiology, general biology, general genetics, general cell biology, immunology and general biotechnology.

Source(s): Data review

Figure 4.
More than a third of the ACRD Research Centre employees had doctorate degrees and came from various fields of Biology

Education Level*



Education Field*



*8% staff education level and field data are missing/not available.

**'Other Scientific Fields' included agriculture, foods and nutrition sciences.



EQUITY, DIVERSITY AND INCLUSION



The ACRD Research Centre’s representation of women and visible minorities exceeded overall workforce availability in 2020-21; however, persons with disabilities and aboriginal people were underrepresented.

The ACRD Research Centre had good representation of Women and Visible Minorities in 2020-21

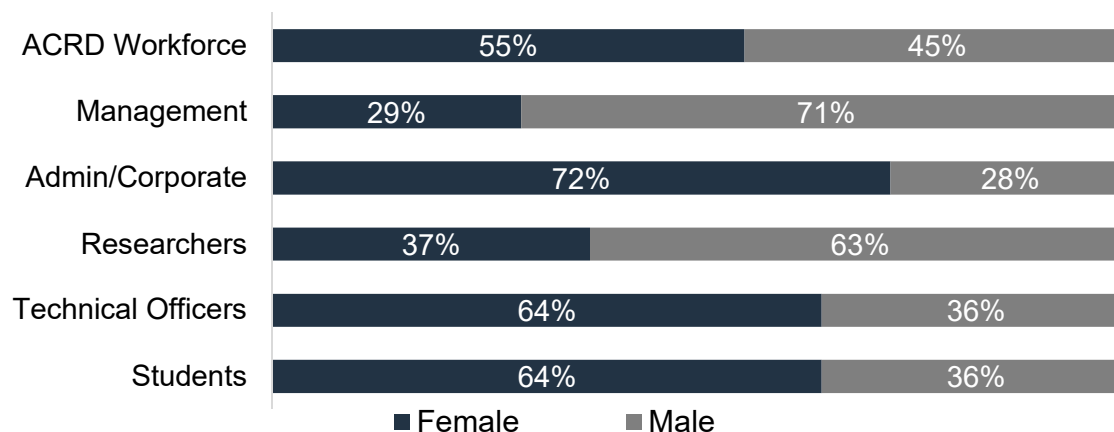
Equity Groups	Representation in ACRD Workforce	Workforce Availability	Gap
Women	53.1%	50.4%	Represented
Visible minorities	31.8%	20.7%	Represented
Persons with disabilities	*	8.1%	Underrepresented
Aboriginal people	*	3.3%	Underrepresented

*Figures of five or less are not reported due to self-identification data confidentiality rules.

Figure 5.

Women made up over half of the ACRD Research Centre’s workforce in 2021-22**

The representation of women in the ACRD research centre is not concentrated in any particular employment subgroup. The gender distribution is also reasonably balanced across different locations.



**Data as of December 23, 2021.

Source(s): Data review





ACRD AND THE IMPACT OF COVID-19

COVID-19 affected the ACRD Research Centre and its targeted clients in a number of ways.

Revenues

- Earned revenues were reduced by more than 50% in 2020-21 as clients cut their R&D budgets to better respond to short term COVID-19 challenges caused by the disruption to domestic and global supply chains. COVID-19 has also made it more difficult to engage new clients.

Project Timelines and Outcomes

- Progress on projects and the achievement of outcomes have been delayed due to the initial shutdown of NRC facilities and the limited access to facilities and ACRD expertise. Overall, clients were understanding of the delays and appreciated the way the research centre supported them during the pandemic.

Stakeholder Engagement

- Development of some stakeholder engagement plans were delayed due to changes to priorities and the assignment of management staff to temporary COVID-19 assignments.
- The research centre found it challenging to engage existing clients through virtual means.

Faced with these challenges, ACRD revisited its operational plans and set new work plans and priorities for 2020-21 and 2021-22.

Support to COVID-19 programs and projects

The research centre also substantially contributed to NRC's pandemic response challenge program and other COVID-19 projects. For example the research centre:

- collaborated with the Human Health Therapeutics Research Centre to support buffer production for Public Health Agency Canada's test kits
- leveraged the plant growth facility to support immediate vaccine development needs
- provided genomics support for VIDO-led SARS-CoV2 vaccine development and viral characterization

Source(s): Document Review, Internal Interviews, External Interviews

Findings from ACRD's COVID-19 Industry Environmental Scan

Agrifood Sector

- Both the global and the Canadian agrifood sectors were substantially affected by the pandemic. As a result, the research focus is shifting more towards safer food processing conditions and product safety with a greater emphasis on productivity.

Marine biotechnology Sector

- Some segments were more affected than others, e.g., seafood processing, oil and gas. The shift in research focus is not as substantial as the Agrifood and Industrial Biotechnology sectors. The sector may play an important role in Canada's post COVID-19 green recovery.

Industrial biotechnology Sector

- Least affected ACRD targeted sector as the disruption caused by the pandemic was mitigated by development, validation and revectoring of existing products to fight the pandemic, e.g., PPE, sanitizers and disinfectants, diagnostic materials. The sector may also play an important role in Canada's post COVID-19 recovery.



OUTCOMES • NRC'S AQUATIC AND CROP RESOURCE DEVELOPMENT RESEARCH CENTRE

The ACRD Research Centre has mostly published in highly cited peer-reviewed journals and compares favourably with Canadian and NRC averages in terms of citation impact. The ACRD Research Centre's scientific publications are aligned with the key sectors of Canadian economy, although the distribution of the ACRD Research Centre's publications across different research areas varied.

The ACRD Research Centre contributed to a number of technology advancements and created new knowledge for its clients. As a result, clients were able to increase their revenues and create new jobs, minimize start-up and operating costs, and enter into disruptive technology research. The research centre also contributed to social security, health and environmental sustainability and supported government policy/ regulations and protein and ocean superclusters.

ADVANCING SCIENTIFIC KNOWLEDGE

The ACRD Research Centre advanced scientific knowledge through publications in highly-cited peer-reviewed journals. These publications also advanced knowledge in key Canadian economic sectors.

The ACRD Research Centre mostly published in peer-reviewed journals

Between April 2015 and October 2020, the ACRD Research Centre produced 343 publications. **Most of these publications were peer-reviewed journal articles (92%).** Nearly half of these journal articles (47%) were published in top journals (based on CiteScore metric), which is higher than both NRC (36%) and Canadian (36%) averages. The ACRD Research Centre also had a higher percentage of publications (19%) in the top 10th percentile of most-cited journals worldwide, again exceeding both NRC (16%) and Canadian (16%) averages.

Citation Impact is higher than the world, NRC and Canadian averages

The ACRD Research Centre's average Field-Weighted Citation Impact (FWCI) stood at 1.51 between 2015 and 2020, meaning that **ACRD Research Centre publications were cited 51% more often than the world average.** The ACRD Research Centre FWCI score is also above the NRC (1.43) and Canadian (1.47) averages.

Source(s): ACRD Research Centre bibliometric study

ACRD Research Centre publications are aligned with key Canadian economic sectors

The Federal Innovation and Skills Plan identified six key strategic sectors in the Canadian economy where the country has significant economic strengths, namely: Health/Biosciences, Agrifood, Advanced Manufacturing, Clean Technologies, Resources for the Future, and Digital Industries. The government's objective is to transform these domestic strengths into global advantages. **Most of the ACRD Research Centre's publications are aligned with these sectors.**



Health/Bio-sciences: 90%



Clean Technologies: 20%



Food: 82%



Resources for the Future: 15%



Advanced Manufacturing: 35%



Digital Industries: 12%

Note: Percentages do not sum up to 100 as multiple key economic sectors could be covered by one publication.



ADVANCING SCIENTIFIC KNOWLEDGE

The distribution of the ACRD Research Centre publications varied across several research areas. The research centre could increase its visibility in marine and industrial biotechnology publications.

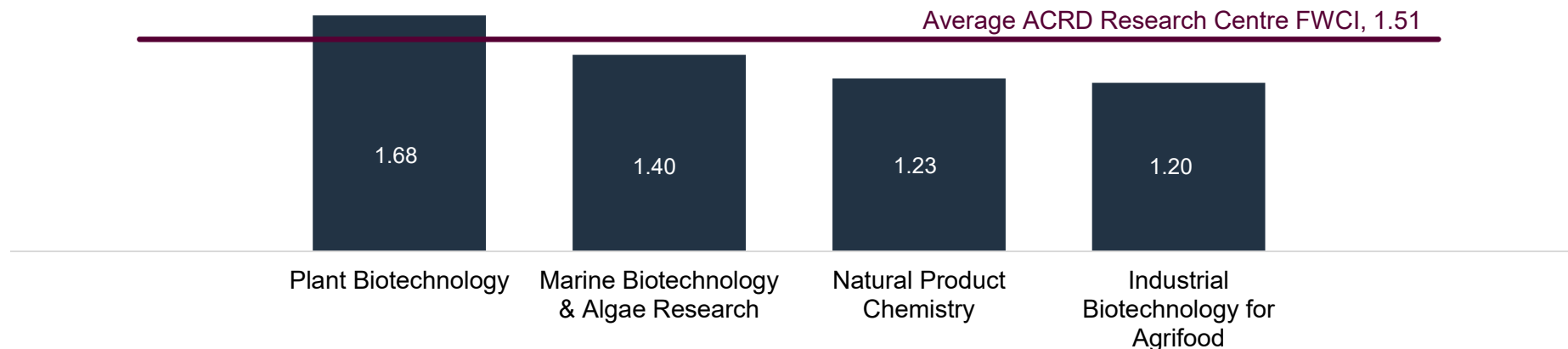
The ACRD Research Centre published most in the area of Plant Biotechnology

Between 2015 and 2020, the ACRD Research Centre published most often in the area of Plant Biotechnology (73% of the total publications). Marine biotechnology and algae research constituted only 20% of total publications. The other ACRD Research Centre publication areas were in natural product chemistry (55% of total publications) and industrial biotechnology for agrifood (60% of the total publications).

Given the existing budget and the nature of the NRC organization (National Research and Technology Organization (RTO) rather than an academic entity), the marine biotechnology peer-review committee was highly impressed with the volume and the quality of marine biotechnology and algae publications. However, the committee noted that restrictions in publishing confidential client information and the research centre's expectation and practice of maintaining a balance between scientific publications and supporting industry work are limiting the number of these publications. In order to increase the visibility of marine biotechnology publications, the committee suggested the research centre publish perspective and/or trend papers in high impact journals.

Figure 6.

Plant biotechnology publications had the highest field-weighted citation impact (FWCI)



Source(s): ACRD Research Centre bibliometric study, Marine Biotechnology peer review



ADVANCING CLIENT KNOWLEDGE AND R&D

The ACRD Research Centre advanced technology readiness levels (TRLs) on client projects and enhanced client R&D agendas.

The ACRD Research Centre advanced knowledge and contributed to technology development

Clients viewed the ACRD Research Centre as a ‘**co-investigator**’ in **developing new knowledge and advancing science and technical solutions**. Most of the survey respondents (85%) reported some degree of advancement in Technology Readiness Level (TRL) in their projects with the ACRD Research Centre. Among them,

- 29% reported advancement of 3 or more levels
- 26% reported advancement of 2 levels
- 29% reported advancement of 1 level

94% of these clients attributed the TRL advancement to the ACRD Research Centre’s involvement in the project. Evidence from survey and key external informants suggested that **the ACRD Research Centre had the biggest impact at the mid-TRL level**.

Increased R&D activities and collaboration

The ACRD Research Centre’s involvement is seen as **instrumental in advancing the R&D agendas** of their clients and collaborators. More than half of the survey respondents (53%) reported increased R&D activities and / or development of R&D infrastructure as a result of their work with the ACRD Research Centre. Some factors that were identified as “key” by clients in advancing R&D agendas include:

- access to the ACRD Research Centre’s world class expertise and information
- access to the ACRD Research Centre’s facilities and advice
- agile and unique services
- proximity and location of the facilities

Moreover, 49% of survey respondents reported **an improved culture of innovation in their organizations**, thanks to their work with the ACRD Research Centre. The common sentiment is that the speed at which work advanced would have been slower without the involvement of the ACRD Research Centre.

The ACRD Research Centre’s research also helped clients (44%) build new partnerships with other organizations.

Source(s): Client survey, external interviews



ECONOMIC IMPACT

The ACRD Research Centre support to Canadian SMEs generated direct (i.e., revenue and job creation) and indirect (i.e., cost savings, reduction to industry entry barriers) economic impacts.

The ACRD Research Centre increased client revenue and job creation

Clients reported increased economic activities as a result of their work with the ACRD Research Centre. Through their activities with the research centre, clients reported a total revenue (actual and projected over the next 5 years) of **\$33.3M from sales, trademarks, copyrights and/or confidentiality/royalty agreements**.

Clients also reported job creation or maintenance due to their work with the ACRD Research Centre (survey respondents identified **19 jobs created and 32 jobs maintained**). Through their research on hemp technology platforms, the ACRD Research Centre also helped small towns, such as Vegreville, AB, develop hemp industrial parks/facilities. These facilities, in turn, helped **restore and rejuvenate the economies** of these towns by creating jobs.

Surveyed clients reported increased economic activities due to their work with the ACRD Research Centre:

- 9% reported creation of new/spin-off businesses
- 22% reported increased production
- 22% reported product/technology commercialization
- 21% reported increased sales and exports

Source(s): Client survey, external interviews

Increased cost savings

Clients reported **substantial operational cost savings** from the ACRD Research Centre's support in clinical trials for various drug developments. One such example is ACRD Research Centre's work with non-mammalian models, i.e., zebrafish models. These models have important impacts for both pharmaceutical SMEs and regulatory clients as they are cheaper, more effective and their use better aligns with public preferences against the use of rodents in experiments. Clients also reported significant cost savings /opportunity benefits from avoiding setting up expensive equipment and analytical facilities and avoiding hiring internal (expensive, high-skilled) expertise.

Reduced barriers to disruptive industry entry

Clients considered the ACRD Research Centre a catalyst in **developing and promoting disruptive technology research for Canadian SMEs**. The ACRD Research Centre's research on alternative protein sources, (e.g., pea, algae protein, algae oil), is examples of such support. Clients noted that Canadian SMEs were facing high barriers to enter into these industries due to significant up-front costs and limited access to high quality expertise/competencies. The ACRD Research Centre significantly reduced these barriers for Canadian SME clients by providing world class facilities and expertise at a reduced rate.



SOCIAL IMPACT



The ACRD Research Centre is contributing to food security and safety issues through its agrifood research and is positioned to improve quality of life through breakthrough and disruptive research in health and biosciences.

The ACRD Research Centre impacts food security and safety

Clients noted that the ACRD Research Centre **contributed to food security by developing different crop varieties and platforms**. Currently, the research centre is working on a project which targets **environmentally-challenged and remote populations**.

This project aims to meet the dietary needs of these communities by researching crop varieties that are indigenous to those environments, e.g., indigenous berries. While it is too early to assess the final impact of the project, key internal informants noted some early benefits of the work. Through the project, **the ACRD Research Centre has added new equipment to Canada's arctic research station and developed an inclusive stakeholder engagement mechanism** which ensured local community representation in project design and operation. Both the equipment and the engagement model are expected to be useful to future projects.

In the food safety sector, the ACRD Research Centre helped to synthesize a nanoparticle biosensor that is expected to impact food safety and regulations.

Source(s): Key stakeholder interviews (external and internal)

Although not a main focus of the research centre, ACRD had an impact on health technology research

Although research on health technologies has not been a major focus of the ACRD Research Centre to date, 27% of the surveyed clients identified improved health technologies stemming from their research with the research centre. Some of the research has the potential to address major health challenges that Canadians face. The ACRD Research Centre is in a position to leverage its expertise to gain additional revenues and bring impacts to clients, as demonstrated by activities to date:

- The ACRD Research Centre's research on **Parkinson's disease formulation** successfully demonstrated a reduction in behavioural changes associated with the loss of dopamine-producing neurons.
- The ACRD Research Centre has provided laboratory services and conducted in-vitro studies to support clients' research on seaweed properties shown to limit growth of breast cancer cells. **This research is considered disruptive in breast cancer treatments** as it promotes the strengthening of the immune system to fight cancerous cells with no side effects.
- The ACRD Research Centre is situated to play a catalyst role in **human heart and pain research** that could substantially impact mortality rates and addiction.



ENVIRONMENTAL IMPACT

The ACRD Research Centre has had environmental impacts through its work on sustainable plants and crops, carbon conversion, algae and zebrafish research.

The ACRD Research Centre developed drought- and pest-resistant technologies and a number of other 'green' technologies

Both government and industry clients identified actual and potential environmental benefits from ACRD research. The ACRD Research Centre has developed **new crops varieties that are able to cope with severe weather events and are more pest-resistant**. Both these factors increase sustainability.

The ACRD Research Centre has a history of working on enzymes. The work has led to the adoption of greener transformation technologies by clients that **reduce the use of chemicals and solvents, and minimize water and energy consumption in agricultural and marine use**.

Through the use of innovative bioresource and processing systems, the ACRD Research Centre's research also produced **protein supplements with a smaller environmental footprint**.

Surveyed clients reported a number of environmental impact due to their work with ACRD:

- 10% reported development of new crop varieties
- 15% reported reduction in crop loss
- 25% reported increased sustainable food sources
- 10% reported reduced use of chemical pesticides or herbicides or chemical fertilizers
- 13% reported increased value from waste resources

Source(s): External interviews, client survey

The ACRD Research Centre's work with the zebrafish model has **generated less biological waste than traditionally-used (mice) models**. This can have an impact at an international level as there is a shift away from animal testing globally. The ACRD Research Centre is currently working with international regulatory platforms to develop a globally-harmonized zebrafish model, e.g., Organization for Economic Co-operation and Development (OECD), National Toxicology program in the USA, the Helm-Holtz Centre for Environmental Research, the Oregon State University and National Institute for Public Health and Environment (RIVM) in Netherlands.

The ACRD Research Centre has done successful pilot projects on photosynthetic efficiency of algae compared to other organisms showing algae's lower environmental footprint.

“The ACRD Research Centre is very proactive about working on drivers and levers that can affect not only the industry and the economy, but also the environment.”

—External Interviewee



IMPACT ON GOVERNMENT POLICIES AND REGULATIONS

The ACRD Research Centre plays an indirect role in developing government policies and regulations. This role could become more significant in the future.

Knowledge generation and de-risking research

Although the ACRD Research Centre does not directly develop government policy or regulations, it does contribute to the development of policy/regulations. The research centre supports evidence-based decision making at both federal and provincial levels through knowledge generation and de-risking research.

13% of the surveyed clients reported ACRD support to government policies, regulations and guidelines. Clients noted that the ACRD Research Centre's **on-going zebrafish work could have significant impacts on federal regulations**. The ACRD Research Centre has a controlled substance laboratory which supports policy and regulation developments in OGDs. Other notable supports include work on **cannabis regulation, product characterization** through the use of chemical barcoding, and work on **environmental safety policy**.

Knowledge and information sharing

The ACRD Research Centre is contributing to a number of inter-governmental committees and working groups at departments including at Fisheries and Oceans Canada (DFO), Agriculture and Agrifood Canada (AAFC), and Natural Sciences and Engineering Research Council of Canada (NSERC). These committees cover a wide variety of topics, ranging from agrifood to oceans, genomics to COVID-19. Notable among these initiatives is ACRD's participation in the Genomics Research and Development Initiative (GRDI) which includes 8 federal departments and agencies. The GRDI undertakes shared priority projects which conduct research on issues that are beyond the mandates of any single department or agency and aim to deliver solutions to enduring and emerging issues for economic, social, and environmental benefits for Canadians. **The ACRD Research Centre is also involved in a global government-level platform, called the International Bioeconomy Forum (IBF).**

The ACRD Research Centre's involvement in these committees provides opportunity to **learn from other science-based departments and engage potential clients**.

“One area [that the ACRD Research Centre could look at in the future to support government policies and regulations] is standards, verification and validation. This helps government make decisions. There will be a huge need to validate statements of veracity of low carbon footprint, etc.”

—OGD Interviewee



SUPPORT TO SUPERCLUSTERS

The ACRD Research Centre is involved with the Protein Industries Supercluster in a significant way, while support to the Ocean Supercluster has been limited to date.

The ACRD Research Centre supports the Protein Industries Supercluster through the Sustainable Protein Production program

The ACRD Research Centre was proactive in supporting Protein Industry Supercluster (PIC) projects through its Sustainable Protein Production (SPP) program. Through the program, the ACRD Research Centre:

- **aligned their capacities** with PIC priorities
- **contributed to two-thirds of PIC projects**
- **brought new projects and stakeholders** to the cluster from their own networks

Internal and PIC stakeholders expect the strong relationship between the PIC and the ACRD Research Centre to continue and to lead to development of pre-competitive research or research applications across the ecosystem as the PIC matures.

The ACRD Research Centre supports the Ocean Supercluster through the marine biotechnology thrust

The ACRD Research Centre supports the Ocean Supercluster, through collaboration with the NRC Ocean, Coastal and River Engineering (OCRE) research centre. The ACRD Research Centre leads the marine biomass assets thrust of the Ocean program.

To date, the ACRD Research Centre support has included **developing proposals, providing scientific advice to proposals**, and other various roles in supercluster projects in the areas of marine biomass utilization and valorization, including algal research, microbial research, and mining and prospecting of ocean biome. However, since the Ocean Supercluster is still in its early days, the ACRD Research Centre support has been limited thus far.

What is a supercluster? Superclusters are collaboration platforms consisting of companies, academic institutions and not-for-profit organizations. The platforms were initiated and co-invested by the Government of Canada to enhance commercially successful innovation, growth and jobs in Canada. Currently, there are five superclusters, targeting five industry sectors: Protein Industries, Ocean, Digital Technology, Advanced Manufacturing, and Artificial Intelligence.



Source(s): Internal and external interviews, document review



RESEARCH FOCUS • NRC'S AQUATIC AND CROP RESOURCE DEVELOPMENT RESEARCH CENTRE

The ACRD Research Centre's focus in agrifood and marine biotechnology is unique in Canada and is aligned with the needs and priorities of Canadian small- and medium-sized enterprises (SMEs), academia and the federal government. However, the research centre could benefit from further narrowing its focus to concentrate on areas where it can have maximum impact in a more sustainable way.



RESEARCH FOCUS – UNIQUENESS AND ALIGNMENT

With a unique research focus on the Canadian bioeconomy ecosystem, the ACRD Research Centre has aligned its research areas with the needs and priorities of various stakeholders.

The ACRD Research Centre’s research is unique; there are very few instances of duplication with other stakeholders in the ecosystem

Clients noted that, for the most part, the ACRD Research Centre is unique in its research focus on both the agrifood and marine biotechnology side. **Only 6% of survey respondents reported extensive duplication** with other organizations, and 4% reported moderate duplication. Most external key informants view the research centre as occupying the “middle space” of the innovation spectrum, **acting as a bridge between basic research done by universities and the commercialization research required for industry applications**. These clients noted that there are not many other players in the ecosystem positioned to provide services in this space. However, there is some limited duplication with other federal departments, e.g., in low TRL protein extraction research. Federal government clients noted that a better information flow between the ACRD Research Centre and other federal government departments could reduce these duplication and further improve alignment.

The ACRD Research Centre’s research is aligned with the needs and priorities of Canadian SMEs, academia and government

The ACRD Research Centre has refined its priority areas over time **in response to changing stakeholders needs**. Canadian industry and academia clients indicate that the ACRD Research Centre’s forward looking strategy in agrifood and marine biotechnology are **aligned with their needs and priorities, both in terms of research areas and the technology readiness level of the research**. The ACRD strategy is also aligned with major federal government initiatives, such as the Protein and Ocean superclusters, and high-level plans and priorities of Canadian federal and provincial governments, e.g., modernizing and improving the efficiency of agrifood supply and management system, growing the Canadian agrifood sector and improving Canada’s food security, and supporting the federal Blue Economy Strategy etc.

Federal and provincial government clients are satisfied with the ACRD Research Centre’s planned research focus for the next five years and stated that the centre is in a good position to help advance their mandates.

Source(s): Client survey, external interviews, internal interviews, document review



RESEARCH FOCUS – AREAS FOR IMPROVEMENT

The ACRD Research Centre focus is quite broad and could be narrowed to further maximize impact. In addition, the research centre's strategic plan could benefit from the explicit inclusion of views and preferences of remote, northern and Indigenous communities.

The ACRD forward-looking strategic plan could use an update to ensure maximum impact

The marine biotechnology peer-review committee agreed with industry, academia and government clients in concluding that the ACRD Research Centre's work on microalgae, seaweed, microbes, enzyme and aquaculture are aligned with the needs of all the marine biotechnology stakeholders in the Canadian ecosystem. The committee suggested however that the research centre's focus is too diverse, and suggested some areas where they could focus to ensure maximum impact. These areas include **aquaculture and sustainable feed development** (especially the effects of oil pollution, nutrients, pH and temperature on micro algal communities and hydrocarbon degradation) and research relevant to the effects of land-based, agriculture and sea cage aquaculture. The committee also indicated that the ACRD strategy **concentrates primarily on adding 'value', rather than developing sustainable commodities**. The committee suggested a move to more substantially support 'social sustainability'.

According to the marine biotechnology peer-review committee, ways to bolster a sustainability focus include: participating in and communicating with EU research programs on the blue economy, learning from EU experiences on ecology and greener economy practices, and developing metrics to exclusively capture environmental impacts. On the agrifood side, precision and smart agriculture were identified by clients as areas where the ACRD Research Centre could engage more.

The needs of Indigenous communities have been considered in both agrifood and marine biotechnology, although not in a systematic way. The research centre's Sustainable Food System (SFS) Initiative has a deliberate thrust engaging northern, remote and Indigenous communities. On the marine biotechnology side, the research centre is working with the Ocean Supercluster, which has a mandate to work with Indigenous and northern communities. **The preference of these communities, however, have not been systematically identified and represented in the current ACRD strategic plan.**



Source(s): Marine Biotechnology peer review, external interviews, internal interviews, document review



STAKEHOLDER ENGAGEMENT • NRC'S AQUATIC AND CROP RESOURCE DEVELOPMENT RESEARCH CENTRE

The ACRD Research Centre currently engages a considerable number of key industry and R&D players active in Canada in its focused research areas. The research centre also engages with two superclusters: the Protein Industries Canada (PIC) supercluster and the Ocean supercluster. The majority of the ACRD activity, however, has been focused on supporting Canadian SMEs. Given the substantial stake and influence of large companies in the Canadian marine bioeconomy ecosystem, the ACRD Research Centre could enhance its impact by engaging more large marine biotechnology companies. In addition, the research centre could better integrate and leverage connections of the Industrial Research Assistance Program (IRAP).



ACRD RESEARCH CENTRE STAKEHOLDERS

The ACRD Research Centre engages with various stakeholders in the ecosystem (Canadian and foreign industry clients, Canadian provincial and federal government departments and national and international academia). The majority of its activities, however, have been to support Canadian industry clients, mainly SMEs.

The ACRD Research Centre is well-known in the Canadian bioeconomy ecosystem and engages with key national players

The ACRD Research Centre is well known in the Canadian ecosystem. The research centre is **currently engaged with one quarter of key Canadian industry and R&D players** on plant biotechnology, marine biotechnology, natural product chemistry and industrial biotechnology.

Current engagement, however, is **primarily with Canadian SMEs**.

The marine biotechnology peer-review committee highly appreciated the role the research centre plays for these SMEs at an early stage to share risk and accelerate innovation. The committee, however, noted that **large companies play an important role in marine biomass and food areas in Canada**, especially in the Canadian feed industry, and currently the ACRD Research Centre does not have a comprehensive strategy to involve these companies. **In order to engage with these larger companies**, the committee suggested the research centre leverage their analytical capabilities to characterize, process and improve bulk land-based plant ingredients, insects, food waste and animal biomass sidestreams for sustainable aqua feed applications.

Source(s): Data review, Marine Biotechnology peer review

Figure 7.
Revenues - Technical services

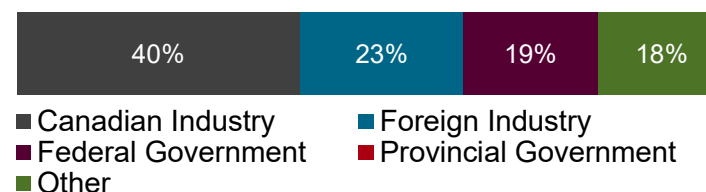
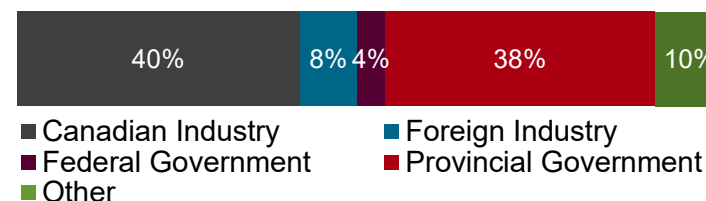


Figure 8.
Revenues - Strategic R&D



The marine biotechnology peer review committee also recommended **partnerships with maritime networks**, such as Réseau Québec Maritime (RQM), Institut sur la Nutrition et les Aliments Fonctionnels (INAF), Centre de Recherche en Biotechnologie Marine (CRBM), to promote multidisciplinary and multi-institutional research, particularly in the areas of nutrition and health. On the international side, the committee suggested more collaboration, especially in, **aquaculture research opportunities with Norway and Iceland**.



STAKEHOLDER ENGAGEMENT PLANS

A number of engagement plans are currently under development

The ACRD Research Centre does not have a documented stakeholder engagement plan. However, the development of **an overarching engagement plan for the research centre is currently underway**, led by the Business Management Services (BMS) group within NRC. As well, to date, there is also no engagement plan for the individual ACRD Research Centre facilities.

“It’s not that we don’t have a plan; it’s just not well documented... especially during COVID times, when communications are not as good as they used to be. You need to have a good documentation system and make sure every document is accessible to everyone to execute”

—Internal Interviewee



At the program level, the **Sustainable Protein Production (SPP) program is the only program with a full-scale stakeholder engagement and marketing plan** for internal NRC stakeholders, external strategic partners, clients, and the general public. The plan also identifies potential strategic partnerships and opportunities, including Statements of Work (SOWs) for projects that support Protein Supercluster members. This plan was assessed as thorough and robust by the SPP peer review committee at the time of the establishment of the program. Progress against the plan is tracked on a weekly basis.

Though not well developed, both the Marine Biotechnology research theme and the Industrial Biotechnology technology platform have strategic engagement plans. Client relationship leads (CRLs) meet regularly to discuss engagement strategies, as well as the availability of researchers and facilities for potential opportunities in these programs.

Internal interviewees noted that the systematic development and documentation of these engagement plans were interrupted due to **changes in research centre structures and priorities and the redeployment of research centre management to COVID-19 priorities.**



OUTREACH ACTIVITIES

The ACRD Research Centre participates in a range of outreach activities, although many outreach activities were substantially impacted by COVID-19.

The ACRD Research Centre undertakes various activities to engage with its stakeholders

CRLs and the ACRD Research Centre researchers are involved in wide-ranging outreach activities. Among them, participation in annual conferences, tradeshow and reaching potential clients for 'face-to-face' conversations seem to be the major outreach activities of the research centre.

Outreach activities have been impacted by the COVID-19 pandemic

Major outreach activities have been significantly impacted by COVID-19. Currently, there is a limited number of virtual industry conferences available to attend. In addition, there are limited opportunities for direct outreach methods (e.g., 'face-to-face' conversations), considered the most effective outreach method.

“Number of small companies that we work with in the ACRD Research Centre is disproportionately higher than other research centres at the NRC. A lot of them are early stage companies too, trying to raise money. COVID-19 has been the huge distraction.”

—Internal Interviewee



The impact of COVID-19 on Canadian SMEs, in the form of widespread supply chain disruptions and credit challenges, make it difficult for the ACRD Research Centre to reach and engage new clients as their focus is elsewhere. The recent hold on the IRAP certificate program may further challenge engagement activity since the fund was useful in engaging ACRD clients with low R&D budgets. In 2020-21, ACRD projects under the IRAP certificate program accounted for 33% of the research centre's revenues. On a positive note, however, international outreach activities are becoming easier due to the use of new virtual tools and people's ability to quickly adapt to these tools.

Source(s): Document review, data review, internal interviews



RELATIONSHIP WITH INDUSTRIAL RESEARCH ASSISTANCE PROGRAM (IRAP)

The ACRD Research Centre collaborated with IRAP to integrate their market and client knowledge, in order to improve client engagement. Further collaboration with the IRAP could be beneficial to the research centre.

Increased IRAP engagement could bolster ACRD Research Centre access to Canadian SMEs who would benefit from ACRD expertise

The research centre's agrifood segment and IRAP have made efforts to collaborate over the last 2 years to engage new clients. The ACRD Research Centre has begun participating in IRAP Agrifood and Bioproduct sector team meetings and has established working relationships between several research officers and IRAP Industrial Technology Advisors (ITAs) in an effort to access IRAP market intelligence to reach and engage clients. However, **increased collaboration with IRAP could be of benefit.** Stakeholders suggested there may still be opportunities to enhance connections.

The ACRD Research Centre could benefit from collaboration with IRAP when developing stakeholder engagement plans, given IRAP's understanding of the current state of industry and technology development opportunities. One suggested approach for facilitating such collaboration is the creation of **a shared platform enabling deliberate conversations** amongst ACRD senior management, CRLs, ACRD researchers, ACRD IRAP representatives and IRAP ITAs.

“The work with IRAP needs to be more co-ordinated at the (ACRD Research Centre) senior management level. We need to find a mechanism and we need to make it a priority for having more deliberate conversations”

—Internal Interviewee



CAPACITIES, COMPETENCIES AND FACILITIES • NRC'S AQUATIC AND CROP RESOURCE DEVELOPMENT RESEARCH CENTRE

The ACRD Research Centre is well-recognized for its scientific and technical expertise. However, there are challenges to maintain the reputation. The ACRD Research Centre has prioritized implementation of strategic hiring and resource development strategies to attract critical expertise and build new capabilities. The outcome of these strategies will largely depend on the ACRD Research Centre's ability to deal with some NRC wide administrative challenges.

The majority of the ACRD Research Centre facilities are in need of upgrades and/or expansions. There are some potential collaborative opportunities which the research centre can pursue to address its gaps in facilities.

CAPACITIES AND COMPETENCIES

The ACRD Research Centre is well-recognized for its scientific and technical expertise in a number of areas. However, an aging workforce and difficulties in attracting and retaining the right expertise could challenge the research centre moving forward.

The ACRD Research Centre is recognized for its competencies and expertise, although an aging workforce could lead to problems in the future

The ACRD Research Centre's expertise on **micro and macro algae, genomics and plant biotechnology** are highly regarded by clients. Two thirds of the surveyed respondents (67%) cited the ACRD Research Centre researchers' scientific knowledge as the primary reason to work with the research centre, and acknowledged that they would be likely to work with them again. 84% of surveyed clients and collaborators reported that the ACRD Research Centre had the expertise required to fulfil their project objectives to a significant extent. The marine biotechnology peer review committee agreed and added that the marine biotechnology researchers have significantly improved their expertise over the years. They further noted that the research centre currently has **excellent capabilities in bioprospecting, and extraction and characterization of high value compounds**.

The ACRD Research Centre, however, faces challenges in hiring permanent staff with the right expertise due to limited supply of, and high demand for, this expertise in Canada. A lengthy hiring process (a government and NRC wide challenge) also delays hiring. It should be noted however that, as supported by the views of clients, the ACRD Research Centre has done a good job of managing, within its existing wage envelope, to attract highly talented staff.

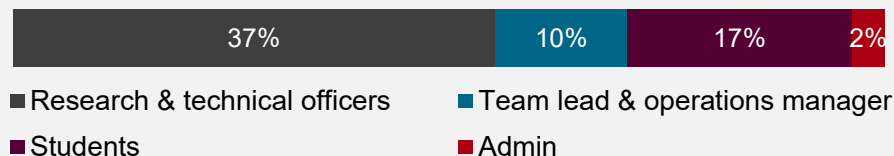
Source(s): Client survey, internal interviews, external interviews, Marine Biotechnology peer review, document review, data review

Also, in 2026, approximately a quarter of ACRD employees will be eligible to retire. Facing these challenges, ACRD Research Centre leverages the use of short-term hires and took a number of steps to address its hiring needs.

The research centre made progress to address EDI gaps in its workforce

During 2020-21, the **ACRD Research Centre hired more women than men (66% vs 34%)**, and most of these women were hired in research and technical positions.

Figure 9.



The ACRD Research Centre's Northern Food project in Gjoa Haven, Nunavut, has recognized the importance of community hiring to understand relevant needs and opportunities of the community. Through collaboration with the Arctic Research Foundation, ACRD researchers have integrated seven community members into the project.



CAPACITIES AND COMPETENCIES

Building competency through internal collaboration and cross-training

The ACRD Research Centre has indicated that they collaborate with other NRC research centres to gain access to additional resources and needed expertise. Some examples include:

- exploring joint projects to develop and launch new technologies for Agrifood, and Supercluster opportunities with numerous NRC research centres,
- using the Energy, Mining and Environment (EME) Research Centre's bio refinery plant and carbon conversion capabilities and the Human Health Therapeutics (HHT) research centre fermentation facilities and capabilities,
- cross-training with the EME research centre.

As noted earlier, the ACRD Research Centre also worked with other NRC research centres to deliver on COVID-19 mandates.

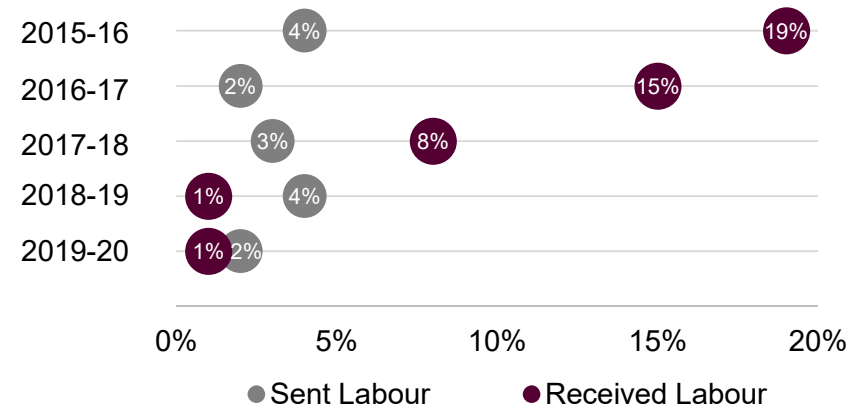


How many other NRC Research Centres does ACRD work with? Over the evaluation period, ACRD worked with the following Research Centres: Digital Technologies; Aerospace; Advanced Electronics and Photonics; Automotive and Surface Transportation; Nanotechnology; Human Health Therapeutics; Energy, Mining and Environment; and Metrology.

Source(s): Document review, data review, internal interviews

However, an analysis of labour sharing data reveals that the ACRD Research Centre's labour sharing with other NRC research centres has declined substantially since 2015-16 especially the percentage of labour received from other research centres. This is likely a result of the change to the ACRD program model.

Figure 10.
ACRD's Labour Sharing with other NRC research centres fell during the evaluation period



Challenges identified in working with other research centres, which could also be contributing to the decline over the years, include: diverging research mandates and priorities, confusion regarding project ownership and management, and issues related to revenue attribution and mechanisms for cost-sharing (note that these challenges are not unique to the ACRD Research Centre).

CAPACITIES AND COMPETENCIES

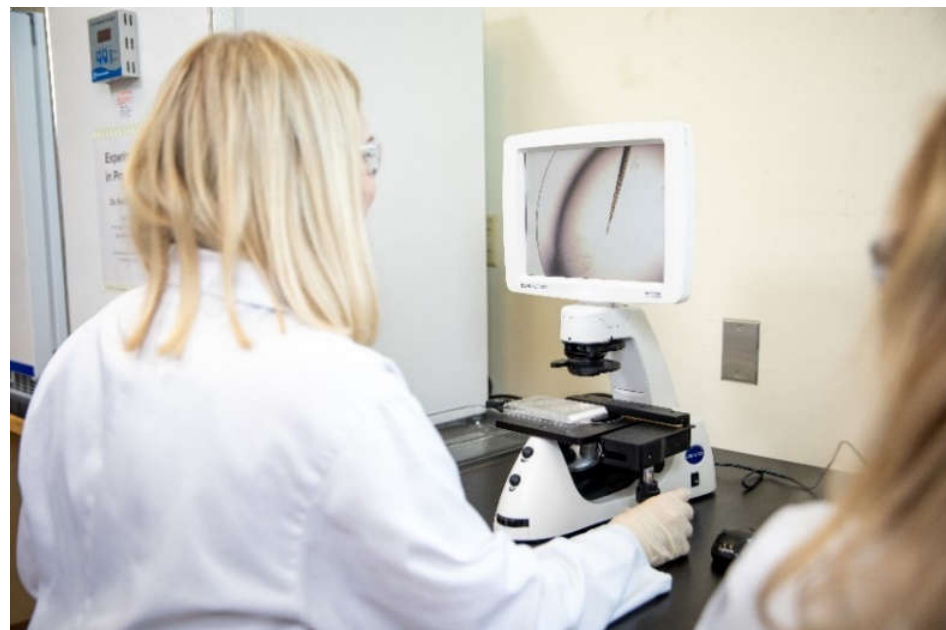
Leveraging the use of post-doctoral fellowships (PDFs) and student programs

The ACRD Research Centre also made use of Post Doctoral Fellows (PDFs) to gain access to skilled resources. However, the research centre faces challenges in converting these PDFs into full-time positions while staying within its current wage envelope. The centre is looking at incremental funding opportunities by exploring opportunities to align and participate in new government priority initiatives that offer incremental permanent or temporary funding.

Use of internal projects for competency development

During the evaluation period, the ACRD Research Centre recorded a total of 273 internal projects, of which 94% were strategic R&D. **Strategic R&D projects present an excellent opportunity for researchers to focus on early-stage discovery and/or fundamental research, and to develop new staff competencies.** These projects also provide a platform to respond to the needs and preferences of diverse/under-represented populations.

Source(s): Document review, data review, internal interviews



The ACRD Research Centre developed significant expertise in zebrafish research over the evaluation period.

Skills development through training

The ACRD Research Centre took advantage of a number of training opportunities over the evaluation period. **Training expenditures for ACRD researchers (excluding expenditures on language training), grew by 103% between 2015-16 and 2018-19** (2019-20 is treated as an outlier year due to COVID-19 and hence was excluded from the growth calculation).

THE ACRD RESEARCH CENTRE FACILITIES

ACRD facilities were generally viewed as unique, within Canada, and highly-specialized, with some recognized for having research capabilities and/or equipment that were limited across the world. However, better facilities may exist elsewhere in some areas and substantial capital investment is needed to maintain and upgrade others.

ACRD facilities support project needs but some needs investment

The majority of the ACRD Research Centre facilities are unique and highly specialized within Canada, meeting the needs of most clients and collaborators to a “significant extent”. Some of the ACRD research capabilities and equipment are leading-edge internationally, including the research centre’s marine algae cultivation capacity ranging from 100 microlitres to 2000 litres, 1.2 GHz nuclear magnetic resonance spectroscopy (NMR) with 1.7mm cryoprobe, high throughput behavioural screening of zebrafish, plant hormone profiling (PHP) platform, and, complex genome assembly capabilities for plant genotypes.



ACRD’s Ketch Harbour facility is a world leading facility in isolation, cultivation, processing and analysis of microalgae and microalgal by-products.

However, many of the ACRD facilities need substantial capital investment. The Plant Growth facility is an immediate concern and delays in finding sufficient funding to upgrade this facility could have a severe impact on the research centre, since this facility is an important revenue source for the research centre. The Plant Growth facility generated over \$10M in strategic research and technical service between 2015-16 and 2018-19.

ACRD’s capabilities in aqua-feed production (located within the algal research facility) and mass spectrometry (located within the natural products & analytical technologies facility) may no longer be competitive, and better capabilities may exist elsewhere in Canada (i.e. within industry and academia).

Consistent with the ACRD Research Centre facility review, the marine biotechnology peer review committee noted limited/no facilities for: aquaculture and valorization of side stream research, algae cultivation in larger-scale downstream processing, heterotrophic organism production, bioactive clinical trials, and for maintaining a large microbe collection.

Both the facility review and the marine biotechnology peer review noted an inadequacy in computational and data management capabilities.

Source(s): ACRD facility review reports, client survey, Marine Biotechnology peer review



THE ACRD RESEARCH CENTRE FACILITIES

Need for major capital investment

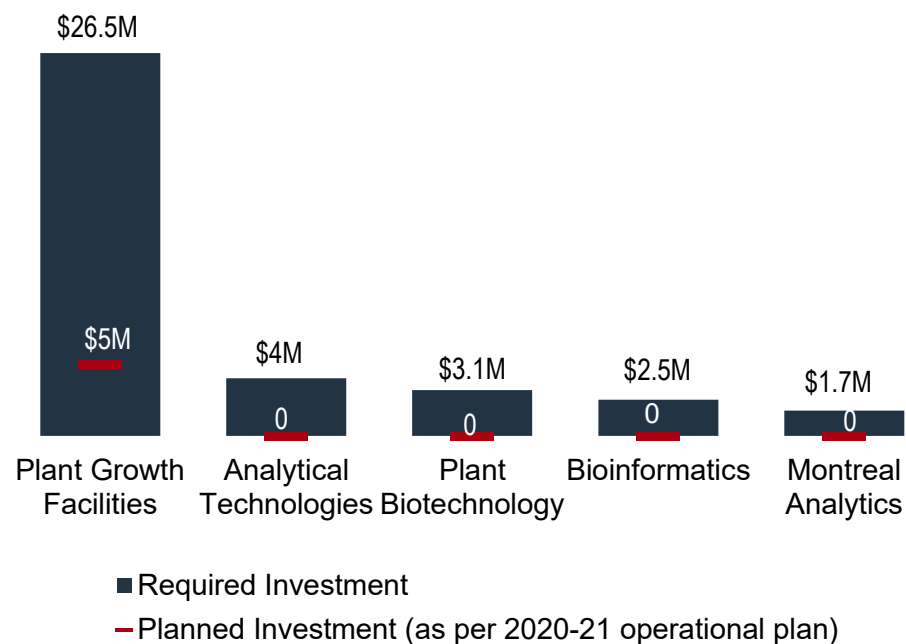
The NRC facilities review exercise indicated that a number of ACRD facilities would require investment. Among these facilities, the Plant Growth Facility requires ‘significant investment’, while the review suggested a need for a capital investment plan, by 2026, for others. According to the ACRD 2020-21 Operational Plan, the research centre currently has two separate investment projects targeting the Plant Growth Facility (totalling \$5M) and the Fermentation/Downstream Processing Facility (totalling \$0.5M), the two most strategically important facilities according to the facility review committee.

However, a comprehensive capital investment plan addressing significant and imminent capital investment needs, as outlined by the NRC Facility Review report, is not available as of yet. The ACRD management team is aware of the need for infrastructure investment within the research centre. As well, it should be noted that in order to address NRC-wide needs for infrastructure investment, NRC senior executives have introduced a 10% reduction to research centre and corporate branch budgets, in order to reinvest in capital infrastructure.

It should be noted that decisions relating to major capital expenditures are made at the NRC level, not at the research centre level.

Figure 11.

Among the top 5 ACRD Research Centre facilities requiring investment, only the Plant Growth Facility has some planned investment as of 2020-21



In order to address the need for facility investments, **the marine biotechnology peer review committee suggested national and international collaboration**, e.g., expanding ‘fermentation’ capabilities by collaborating more with universities, developing downstream capabilities by collaborating with internationally renowned institutes such as the Norwegian Institute of Food, Fisheries and Aquaculture Research (Nofima) and/or Matis.

Source(s): ACRD facility review reports, data review, document review



GEOGRAPHIC DISPERSION • NRC'S AQUATIC AND CROP RESOURCE DEVELOPMENT RESEARCH CENTRE

Geographic Dispersion of the ACRD Research Centre did not substantially affect its efficiency or effectiveness.



GEOGRAPHIC DISPERSION

Although the ACRD Research Centre has a dispersed geographical presence, its efficiency and effectiveness were not affected as a result of this dispersion.

The geographic dispersion of the centre is dictated by the location of the facilities. Any consideration of re-capitalizing facilities should consider the goal of reducing geographic dispersion in order to have critical mass and facilities in fewer locations.

In spite of the geographic dispersion, there is no evidence of substantial operational inefficiency

The evaluation **did not identify any substantial inefficiencies or challenges to the effectiveness of the research centre as a result of geographic dispersion**. Key internal informants indicated that there is good coordination and clarity of roles and responsibilities across the ACRD Research Centre facilities and offices.

Stakeholders identified collaborative work on the strategic plan, weekly discussions about the strategic pipelines, the leveraging of capabilities across sites (where there is expertise), and discussions on emerging project concepts, as activities undertaken to try to manage as cohesively as possible. The ACRD Research Centre teams are also noted to have specific areas of expertise that coincide with geography.



Source(s): Internal interviews

ACRD management took a number of initiatives to reduce the research centre's geographic dispersion, both as a means to limit duplication and enable greater concentration in priority areas

There have been some efforts over the years to minimize the ACRD Research Centre's geographic spread, including the identification of two geographical areas as candidates for consolidation: the NCR (Ottawa) and Montreal sites where ACRD has a minority presence and core competencies also represented at other locations. The ACRD Research Centre recently ended a partnership in a fermentation facility in Saskatoon and is developing this competency in Charlottetown. ACRD also withdrew underutilized fibre milling equipment from Lavaltrie, QC. In addition, activities that have the potential to align within other NRC research centres have been identified as candidates to promote cross-NRC critical mass. However, **a number of factors delayed full implementation of this plan**, including challenges in balancing regional sensitivities and timing of potential change, reluctance within NRC to impact the building of critical mass, and shifts in priorities due to the COVID-19 pandemic.



RECOMMENDATIONS AND MANAGEMENT
RESPONSE AND ACTION PLAN • NRC'S AQUATIC
AND CROP RESOURCE DEVELOPMENT
RESEARCH CENTRE



RECOMMENDATIONS AND SUPPORTING RATIONALE

ACRD strategic plan

- The ACRD Research Centre focus could be too diverse given the limited resource and program timeline.
- The research centre is currently focused on an 'economic/asset driven plan'.
- There has been limited integration of the needs and priorities of remote, northern and indigenous communities in the ACRD research to date.

Recommendation 1

The ACRD Research Centre should expand its forward looking strategic plan to focus on 'sustainability' in agrifood and marine biotechnology research areas where the research centre can have maximum impact. The plan should also better integrate the needs and priorities of remote, northern and indigenous communities.

Visibility of marine biotechnology scientific work

The ACRD Research Centre has relative low visibility of marine and industrial biotechnology publications (relative to plant biotechnology). The peer review committee suggested the research centre increase awareness of the work of the research centre through publishing perspective or trend papers.

Recommendation 2

The ACRD Research Centre should increase the visibility of its marine and industrial biotechnology scientific work by publishing perspective (vision) and/or trend papers in high impact journals.



RECOMMENDATIONS AND SUPPORTING RATIONALE

Engagement, collaboration and outreach strategies

- Large companies have an important stake in the Canadian marine biomass and food ecosystem.
- The ACRD Research Centre mainly engages Canadian SMEs, which may restrict the research centre's ability to grow and have a bigger impact.
- The ACRD Research Centre may not be optimally integrating and leveraging connections with IRAP.
- Existing outreach strategies may not be enough to effectively reach and involve new clients and stakeholders.

Capacities and competencies

- Significant proportion of the ACRD Research Centre staff are already at/nearing the retirement age.
- Majority of the ACRD Research Centre facilities need significant maintenance and/or upgrade to remain competitive.

Recommendation 3

The ACRD Research Centre should include large marine biotechnology companies in its client engagement strategy and increase collaboration with national and international research networks and institutes. Additionally, outreach approaches may need to be revisited to assess their effectiveness in a post-COVID 'new normal' situation.

Recommendation 4

The research centre should increase coordination with IRAP in order to maximize benefits from IRAP's intelligence of Canadian agrifood and marine biotechnology sectors.

Recommendation 5

In order to fill existing or anticipated gaps in competencies and facilities, the ACRD Research Centre should explore ways to expand existing ACRD capacities and capabilities through collaboration with national and international organizations, academic institutions, and other NRC research centres.



MANAGEMENT RESPONSE AND ACTION PLAN

Recommendation 1

The ACRD Research Centre should expand its forward looking strategic plan to focus on ‘sustainability’ in agrifood and marine biotechnology research areas where the research centre can have maximum impact. The plan should also better integrate the needs and priorities of remote, northern and indigenous communities.

Risk-level: low

Management response	Measure of achievements	Proposed person(s) responsible	Expected date of completion
<p>Response: ACRD accepts the recommendation.</p> <p>Action: ACRD will define those aspects of sustainability in the marine and agrifood sectors where ACRD is best positioned to have impact. The needs of remote, Northern, and Indigenous communities, currently more prominent in ACRD’s agrifood activities, will be integrated further into marine activities. In order to achieve these outcomes, resources will be re-deployed from other activities (e.g. the former BSC/IBP programming stream, reduced focus on legacy activities). New pan-ACRD supporting capabilities will be developed.</p>	<p>A1: Specific areas defined for aspects of sustainability in the marine and agrifood sectors where ACRD is best positioned to have an impact, validated through stakeholder consultations.</p> <p>A2: Strategic approaches to build these specific areas of focus, such as new internal/external programs or opportunities for greater ACRD involvement in existing programs (e.g. Northern) developed and resourced.</p> <p>A3: Evidence of implementation of the approaches in the form of specific R&D activities, collaborations, and capacity building projects aligned with the new areas of focus.</p>	<p>Director General, with support from Directors of Research and Business Analyst</p>	<p>March 2024</p>



MANAGEMENT RESPONSE AND ACTION PLAN

Recommendation 2

The ACRD Research Centre should increase the visibility of its marine and industrial biotechnology scientific work by publishing perspective (vision) and/or trend papers in high impact journals.

Risk-level: low

Management response	Measure of achievements	Proposed person(s) responsible	Expected date of completion
<p>Response: ACRD accepts the recommendation, in particular as it pertains to the marine scientific work.</p> <p>Action: ACRD will undertake a dedicated effort to encourage researchers to publish perspective/trend papers, particularly those aligned with the areas of focus identified in Recommendation 1. The strategic goal of transitioning ACRD's industrial biotechnology activities as a platform to support these agrifood and marine foci is expected to also increase the RC's visibility in key areas. Core technologies supporting client services will remain an area for publications to highlight traditional ACRD strengths.</p>	<p>A1: An internal communication plan developed to promote these activities among ACRD researchers and additional resources to incentivize and support targeted publications identified.</p> <p>A2: Most relevant areas for publication and potential authors identified. Annual targets for perspective/trend papers established.</p> <p>A3: A framework to measure the progress in meeting annual targets established. Annual evaluation of progress initiated with corrective actions as required.</p>	Directors of Research, with support of Team Leads	December 2023



MANAGEMENT RESPONSE AND ACTION PLAN

Recommendation 3

The ACRD Research Centre should include large marine biotechnology companies in its client engagement strategy and increase collaboration with national and international research networks and institutes. Additionally, outreach approaches may need to be revisited to assess their effectiveness in a post-COVID 'new normal' situation.

Risk-level: low

Management response	Measure of achievements	Proposed person(s) responsible	Expected date of completion
<p>Response: ACRD accepts the recommendation.</p> <p>Action: As the areas of focus from Recommendation 1 are developed, a profile of key partners to enact the strategic plans will be developed. These profiles will form the basis for developing a targeted stakeholder engagement strategy, a key commitment for ACRD's Business Advisor. ACRD will devote an appropriate level of resources from business development and scientific teams to engage larger companies, as well as national and international networks and institutions, and develop strategic projects and relationships.</p>	<p>A1: Identification of key stakeholders aligned with the strategic profile. In collaboration with the BA and CRLs, an engagement plan will be developed and resourced appropriately.</p> <p>A2: Targets for engagement will be established, with attendant metrics and framework to track progress.</p> <p>A3: Implementation of the engagement plan. Annual evaluation of progress initiated with corrective actions as required.</p>	<p>Director General, with support from Business Analyst, Client Relationship Leaders, and Directors of Research</p>	<p>March 2024</p>



MANAGEMENT RESPONSE AND ACTION PLAN

Recommendation 4

The research centre should increase coordination with IRAP in order to maximize benefits from IRAP's intelligence of Canadian agrifood and marine biotechnology sectors.

Risk-level: low

Management response	Measure of achievements	Proposed person(s) responsible	Expected date of completion
<p>Response: ACRD accepts the recommendation.</p> <p>Action: ACRD will pursue strategies to optimize integration with IRAP in the Biomarine and Agrifood sectors. Coordinating this intelligence with the stakeholder engagement planning of Recommendation 3 will be a priority and a commitment for the ACRD business development team.</p>	<p>A1: Joint IRAP/ACRD meetings will be held for each of the two sectors, including working with regional IRAP directorates as well as the relevant sector teams.</p> <p>A2: Strategies for closer collaboration and intelligence sharing will be developed in partnership with IRAP.</p> <p>A3: Strategies to maintain and grow the interactions will be incorporated into ongoing RC ops, strategy, and business development plans.</p>	<p>Director General, with support from Directors of Research and Business Analyst</p>	<p>June 2023</p>



MANAGEMENT RESPONSE AND ACTION PLAN

Recommendation 5

In order to fill existing or anticipated gaps in competencies and facilities, the ACRD Research Centre should explore ways to expand existing ACRD capacities and capabilities through collaboration with national and international organizations, academic institutions, and other NRC research centres.

Risk-level: moderate

Management response	Measure of achievements	Proposed person(s) responsible	Expected date of completion
<p>Response: ACRD accepts the recommendation.</p> <p>Action: ACRD will expand existing competencies and capacities through collaboration, as part of its strategy to maintain and further develop its agrifood and biomarine facilities, similar to the atypical fermentation facility partnership in PEI and the proposed Prairie Plant Technology Centre in Saskatoon. A framework for this strategy will be supported by the foci and stakeholders identified in Recommendations 1 and 3. ACRD's previously outlined refocussing and geographical streamlining strategy will provide one avenue to identify resources and achieve the optimal level of concentration and financial sustainability.</p>	<p>A1: Engagement plan developed in response to Recommendations 1 and 3 will include aspects of facility and competency sharing as key criteria for potential partners.</p> <p>A2: A timeline and framework for acquiring key new near and long term capacities and competencies will be established.</p> <p>A3: Stakeholder engagement plans will be executed and high potential partner opportunities identified. Targets and timelines to meet them will be refined.</p> <p>A4: The previously established refocussing and geographical streamlining strategy will be executed.</p>	<p>Director General, with support from Director's of Research, Business Analyst, and Directors of Operations</p>	<p>March 2024</p>



**APPENDICES • EVALUATION OF NRC'S AQUATIC
AND CROP RESOURCE DEVELOPMENT
RESEARCH CENTRE**



APPENDIX A – METHODOLOGY

Bibliometric study



NRC's Library and Information Management Services (LIMS) conducted a bibliometric assessment. The ACRD Research Centre publication dataset was compiled by searching the Scopus database for all NRC-affiliated publications for the period 2015 to 2020. The ACRD Research Centre publications were identified based on references to ACRD in the metadata or authorship (as of October 2020). The list was validated by the research centre.

Data review



The ACRD Research centre and performance data for 2015-16 to 2020-21 were reviewed to provide information on inputs (i.e., resources), outputs, and client reach. These included financial data, human resource data, project data and intellectual property data.

Key informant interviews



Interviews were conducted with 32 stakeholders (13 internal and 19 external) to collect information such as personal experiences, opinions and expert knowledge related to the relevance, engagement and performance of the ACRD Research Centre. This information was used to complement other lines of evidence and to contextualize quantitative information.

Client survey



A web-based survey was conducted of all the ACRD Research Centre clients and collaborators (except clients for materials transfer agreements) between April 2016 and October 2021, to assess the impact and engagement practices of the research centre (n=560). COVID-19 seemed to have an impact on the response rate. Follow-up calls were conducted to increase the response rate, which finally stood at 14%. This rate offered the survey result a 95% confidence level, with a 10% margin of error. Where available, interview input was used to complement survey findings.

Document review



Internal and external documents were reviewed to provide context and to complement other lines of evidence in assessing relevance, engagement and performance.

Limitations and mitigations



Use of Publications to Measure Excellence

The use of FWCI as a measure of scientific excellence introduces a limitation associated with the fact that there is a time lag for citation of published work. As a result, scientific excellence of more recent publications is likely underestimated in the current study. To mitigate this limitation, other lines of evidence were used to assess the excellence and scientific impact of the ACRD's research.



APPENDIX A – METHODOLOGY

Peer review committee



A peer review committee (PRC) was convened to assess the relevance, engagement, excellence and resources of the ACRD Research Centre in marine biotechnology research. The PRC was composed of six experts from Canada, the Netherlands, Norway, Portugal and France with a range of expertise in marine biotechnology. To ensure objectivity and avoid conflicts of interest, peer review committee members with no, or limited, connections to the NRC were selected, and all members signed a confidentiality and conflict of interest agreement.

PRC members examined a package of prepared materials prior to participating in a pre-assessment call and 3 virtual peer-review sessions. Virtual sessions included presentations and poster sessions delivered by the research centre, and discussions with the ACRD Research Centre's Director General, senior management and marine biotechnology researchers and team leads.



**Dr. René H. Wijffels,
Committee Chair**

Professor and Chairholder of Bioprocess Engineering Group at Wageningen University and Scientific Director of AlgaePARC.



Dr. Lucie Beaulieu

Professor of Food Science at the Université Laval, board member at the institute of Nutrition and Functional Foods, Director at the Quebec Maritime Network and Group Leader at the Institut France-Québec maritime.



Dr. Claire Hellio

Professor of Marine Biotechnology and director of BIODIMAR at the Université de Bretagne Occidentale.



**Dr. Katerina
Kousoulaki**

Senior Nutrition Researcher at the Norwegian Government Institute of Food, Fisheries and Aquaculture Research (Nofima)



Mr. João Navalho

Co-founder and President at Necton S.A., Co-founder, director and former president of PROALGA and co-founder and vice-president of GreenCoLab.



Dr. Mette Sørensen

Professor and Dean at the faculty of Biosciences and Aquaculture, Nord University.

