# NOVA SCOTIA AQUACULTURE REVIEW BOARD

**IN THE MATTER OF:** Applications made by TOWN POINT CONSULTING INC. for NEW MARINE SHELLFISH LICENCES/LEASES in ANTIGONISH HARBOUR, ANTIGONISH COUNTY for the SUSPENDED CULTIVATION of AMERICAN OYSTERS (AQ#1442, #1443, and #1444)

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## AFFIDAVIT OF EXPERT WITNESS – JON GRANT

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I, JON GRANT, of Halifax, in the Province of Nova Scotia, HEREBY MAKE OATH AND SAY AS FOLLOWS:

1. I am a resident of Halifax, Nova Scotia.

2. I am presently employed as a Professor with the Department of Oceanography at Dalhousie University. Attached to my affidavit as Exhibit "A" is a true copy of my curriculum vitae, setting out my expertise, education and training.

3. Attached to this affidavit as Exhibit "B" is a statement of the substance of my proposed evidence.

4. I make this affidavit in connection with the Applications made by Town Point Consulting Inc. for New Marine Shellfish Licences/Leases in Antigonish Harbour for the Suspended Cultivation of American Oysters and for no improper purpose.

SWORN/AFFIRMED before me by )
videoconference from St. John's )
Province of Newfoundland and Labrador, )
this 24th day of May, 2023 )

[signature] )

**Rebecca Shiels** )
A Commissioner of the Supreme Court )
of Nova Scotia )

Location: Halifax, NS )

[signature]
JON GRANT, PhD

Location: St. John's NL

REBECCA SHIELS
A Commssioner of the Supreme
Court of Nova Scotia
My Commission expires Dec. 14, 2027

This is **Exhibit "A"** referred to in the Affidavit of JON GRANT sworn before me on May 24, 2023

REBECCA SHIELS
A Commssioner of the Supreme Court of Nova Scotia
My Commission expires Dec. 14, 2027

**Name/Affiliation**

Jon Grant, Department of Oceanography, Dalhousie University,
Halifax Nova Scotia B3H 4R2 [redacted]@dal.ca)

**Education/Training**

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| 1981 | Ph.D., Biology, University of South Carolina |
| 1976 | B.Sc., Zoology, Duke University |

**Employment/Affiliations**

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|---|---|
| 2014-2021 | NSERC-Cooke Industrial Research Chair in Sustainable Aquaculture, Dalhousie University |
| 2011-2016 | Killam Professor of Oceanography, Dalhousie University |
| 1997- | Professor, Department of Oceanography, Dalhousie University |
| 1992-1997 | Associate Professor, Department of Oceanography, Dalhousie University |
| 1987-1992 | Assistant Professor, Department of Oceanography, Dalhousie University |
| 1983-1986 | Research Associate, Department of Oceanography, Dalhousie University |
| 1981-1982 | NATO Postdoctoral Fellow, Department of Oceanography, Dalhousie University |
| 2018- | Adjunct Professor, Health Management, Atlantic Veterinary College, University of Prince Edward Island |
| 2004-2009 | Professeur Associé, Institut des Sciences de la Mer de Rimouski, Université du Québec à Rimouski |
| 2000 | Adjunct Professor, Aquaculture, Yellow Seas Fisheries Research Institute, China |
| 1994 | Distinguished Visiting Scientist, Water Quality Centre, National Institute of Water & Atmospheric Research, New Zealand |

**Recent Research Programs**

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|---|---|
| 2022-2024 | A province-wide tool for aquaculture carrying capacity in Nova Scotia, Atlantic Fisheries Fund |
| 2021-2023 | Big Data and precision fish farming in Nova Scotia, Atlantic Fisheries Fund |
| 2018-2021 | Green Aquaculture Intensification (GAIN), EU Horizon 2020 |
| 2018-2022 | NSERC Collaborative Research & Development Grant, Operational management of sustainable fish farming |
| 2016-2023 | Ocean Frontier Institute (CFREF) – Module K, Novel sensors for fish health and welfare (Leader) |
| 2016-2023 | Ocean Frontier Institute (CFREF) – Module M, Social license and planning in coastal communities |
| 2014-2021 | Industrial Research Chair in Sustainable Aquaculture, NSERC Industrial Research Chairs |

**Most Significant Contributions**

I am responsible for the development of several major research areas in coastal oceanography, creating a body of literature on aquaculture–environment that is as substantive as any in the world. In 2013, I partnered with Cooke Aquaculture, a global leader in fish farming to become the NSERC-Cooke Industrial Research Chair in Sustainable Aquaculture.

My present research may be categorized as follows:

- Benthic impacts of aquaculture
- Ecosystem modelling and marine spatial planning in the context of aquaculture
- Criteria for aquaculture carrying capacity sustainability including ecosystem modelling and field measurements (e.g. macroalgal bioassays)
- Ocean technology applied to aquaculture, including fish behaviour
- Decision support for turning science into management

Aside from aquaculture, I have a long career in benthic ecology involving animal-sediment relations from the intertidal to the deep-sea, including the Arctic. Habitat mapping using Biosonics echosounding as well as aerial drones is central to my recent work. This includes macrophyte and sediment type mapping. I was a PI in NOW, CASES, CHONe I, and the CFI grant that originally funded the CCGS Amundsen .

I have several large research programs in Canada and Europe which include assessment of (a) regulations governing fish farming, (b) new software decision support based on ecosystem models, (c) modes of evaluating benthic impacts, (d) sensor arrays and internet of things for precision aquaculture. I also have extensive collaborations with the Atlantic Veterinary College on epidemiological models of farmed fish health and InnovaSea on acoustic sensors. HQP supervision has involved ~70 MSc, PhD, BSc and postdocs over the years. I presently supervise 3 PhD students and 1 MSc and graduated 4 MSc students in 2020-21. My collaborations with Indigenous partners beyond the Eastern and Western Arctic involve Haida Gwaii (clam habitat mapping, ecosystem modelling) and the We'koqma'q Fish Farm (benthic studies in NS).

**Recent Publications**

Stockwell, CL, R Filgueira, J Grant. Submitted.The effects of oxygen supplementation on farmed Atlantic salmon (*Salmo salar*) behavior using acoustic telemetry. Aquacult. Engineer.

Rector ME, J Weitzman, R Filgueira, J Grant. 2022. Indicators of salmon aquaculture impacts: a systematic review. Reviews in Aquaculture 14: 156-177.

Sutherland T, CL Amos, J Grant. 2022. Resuspension and deposition of biomediated sediments in Upper South Cove, Nova Scotia, Canada. J. Coast. Res. 38: 19–34.

O'Donncha F, CL Stockwell CL, S Rey Planellas, G Micallef, P Palmes, C Webb, R Filgueira, J Grant. 2021. Data driven insight into fish behaviour and their use for precision aquaculture. Frontiers in Animal Science 28: 695054.

Stockwell, CL, R Filgueira, J Grant. 2021. Determining the effects of environmental events on cultured Atlantic salmon behaviour using 3-dimensional acoustic telemetry. Frontiers Anim. Sci. 2: 701813.

Rector ME, R Filgueira, J Grant. 2021. Ecosystem services in salmon aquaculture sustainability schemes. Ecosystem Services 52: 101379.

Parent, MI, H Stryhn, KL Hammell, MD Fast, J Grant, R Vanderstichel. 2021. Estimating the dispersal of *Lepeophtheirus salmonis* sea lice within and among Atlantic salmon sites of the Bay of Fundy, New Brunswick. J. Fish Diseases 44: 1971-1984.
McKee A, J Grant, J Barrell. In 2021. Mapping American lobster (*Homarus americanus*) habitat for use in marine spatial planning. Can. J. Fish. Aquat. Sci. 78.
Weitzman J, R Filgueira, J Grant. 2021. Development of best practices for more holistic assessments of carrying capacity of aquaculture. Journal of Environmental Management 287: 112278.
Burke M, J Grant, R Filgueira, T Stone. 2021. Oceanographic processes control dissolved oxygen variability at an Atlantic salmon farm: Application of a real-time sensor network. Aquaculture 533: 736143
Cantrell DL, R Vanderstichel, R Filgueira, J Grant, CW Revie. 2021. Validation of a sea lice dispersal model: Principles from ecological agent-based models applied to aquatic epidemiology. Aquaculture Environment Interactions 13: 65-79.
Filgueira R, T Guyondet, P Thupaki, T Sakamaki, J Grant. 2021. The effect of embayment complexity on ecological carrying capacity estimations in bivalve aquaculture sites. J. Cleaner Production 288: 125739
Filgueira R, T Guyondet, P Thupaki, GK Reid, L Howarth, J Grant. 2021. Assessing the potential for nutrient toxicity on seagrass in the vicinity of an aquaculture site. Journal of Environmental Management 282:111921
Bravo F, J Grant. 2020. Benthic habitat mapping and sediment nutrient fluxes in a shallow coastal environment of Nova Scotia, Canada. Estuar. Coastal Shelf Sci. 242: 106816.
Cantrell D, R Filgueira, CW Revie, E Rees, R Vanderstichel, M Guo, MGG Foreman, D Wan, J Grant. 2020. The relevance of larval biology on spatiotemporal patterns of pathogen connectivity among open-marine salmon farms. Can. J. Fish. Aquat. Sci. 77: 505-519
Cantrell DL, ML Groner, T Ben-Horin, J Grant, Crawford W Revie. 2020. Modeling pathogen dispersal in marine ecosystems. Trends in Parasitology 36: 239-249
Ferreira JG, RG Ferreira, F-J Boogert, RA Corner, JP Nunes, J Grant, J Johansen, WF Dewey. 2020. A multimetric investor index for aquaculture: application to the European Union and Norway. Aquaculture 516: 734600.
Galparsoro I, A Murillas, K Pinabasi, A Sequeira, V Stelzenmueller, AM O'Hagan, A Boyd, S Bricker, JM Garmendia, A Gimpel, A Gangnery, S-L Billing, Ø Bergh, Ø Strand, L Hiu, B Fragoso, J Icely, J Ren, N Papageorgiou, J Grant, P Tett. 2020. Global stakeholder vision for marine aquaculture expansion under an ecosystem-based approach. Reviews in Aquaculture 12(4).
Howarth LM, R Filgueira, S Haas, HB Berry, A McKee, L Steeves, J Grant. 2020. The effects of incubation time, temperature and nitrogen concentration on the isotopic signature ($\delta^{15}N$) of the macroalga *Chondrus crispus*. J. Exp. Mar. Biol. Ecol. 530-531: 151431
Krause G, S-L Billing, J Dennis, J Grant, L Fanning, R Filgueira, M Miller, JP Agúndez, N Stybel, SM Stead, W Wawrzynski. 2020. Visualizing the social in aquaculture: how social dimension components illustrate the effects of aquaculture across geographic scales. Mar. Policy 118: 103985.
Mikkelsen E, Fanning L, C Kreiss, SL Billing, J Dennis, R Filgueira, J Grant, G Krause, D Lipton, M Miller, J Perez, S Stead, S Villasante. 2020. Availability and usefulness of economic data on the effects of aquaculture: A North Atlantic comparative assessment. Reviews in Aquaculture 1-18.

Simone M, J Grant. 2020. Visual based alternatives to sediment environmental monitoring practices. Mar. Poll. Bull. 158: 111367.
Grant, J, M Simone, T Daggett. 2019. Long-term studies of lobster abundance at a salmon aquaculture site, eastern Canada. Can. J. Fish Aquat. Sci. 76: 1096-1102.
Howarth LM, R Filgueira, D Jiang, H Koepke, MK Frame, C Buchwald, S Finnis, T Chopin, SD Costanzo, J Grant. 2019. Using macroalgal bioindicators to map nutrient plumes from fish farms and other sources at a bay-wide scale. Aquacult. Env. Interact. 11: 671-684
O Donncha F, J Grant. 2019. Precision aquaculture. IEEE Internet of Things Magazine 2: 26-30.
Woodin, SA, SS Bell, J Grant, PVR Snelgrove, DS Wethey. 2019. Interactions and processes in shallow water muddy sands of the Northwestern Atlantic Coast. In: Interactions in the Marine Benthos – A Regional and Habitat Perspective, S.J. Lawrence and K. Bohn, eds. Cambridge Univ. Press.

This is **Exhibit "B"** referred to in the Affidavit of JON GRANT sworn before me on May 24, 2023

REBECCA SHIELS
A Commssioner of the Supreme Court of Nova Scotia
My Commission expires Dec. 14, 2027

**Carrying capacity of Antigonish Harbour for oyster culture**

Jon Grant, PhD
Dept. of Oceanography
Dalhousie University

The concept of carrying capacity is a central tenet of modern ecology used to characterize resources that limit population size. For example, an herbivore that overgrazes its food supply might suffer decreased population growth. Carrying capacity has been applied to aquaculture since the 1980's most often to suspension feeding bivalves. Commercially cultured bivalves such as oysters and mussels are known as suspension feeders since they obtain their food from particles suspended in the water. Although there are a variety of particles in suspension (collectively known as seston), the primary nutrition for bivalves derives from microalgae known as phytoplankton.

Food is self-limiting for bivalves; if stocking density is too high and phytoplankton food becomes depleted, bivalves such as oysters will grow to a smaller size and produce less yield for the farmer. Because estuaries are flushed by tides from the open ocean, phytoplankton are renewed from coastal waters daily. Conceptually, carrying capacity in bivalve culture may be viewed as the balance between tidal renewal of phytoplankton, and the extent of their removal by the shellfish. This concept forms the basis of ecological carrying capacity, which is one of the major concepts in aquaculture management. There are other dimensions of carrying capacity including economic (viability), social (public acceptance), and physical (sufficient space) (Weitzman et al. 2021), but ecological carrying capacity is consistent with regulator goals related to conservation and environmental protection.

Carrying capacity may be directly measured only by increasing stocking of bivalves until their growth is compromised; this is an obviously expensive and wasteful exercise, but it has been verified in large scale culture (Heral 1993). In practice, carrying capacity is not directly measured but estimated with a simulation model. I developed these types of models in the late 1980's in collaboration with colleagues including a number of European researchers. Although the application of these models is now widespread, they still require a detailed computer simulation. An understanding of tidal flow, and how it varies within an estuary is a necessary prerequisite and is the basis of a complex physical oceanographic model. Another component of the model deals with oyster bioenergetics coming together with that tidal calculations in a so-called spatial model. These models have been applied to multiple sites in the Maritimes, including bays and estuaries of the Gulf St. Lawrence (e.g. Grant et al. 2008; Filgueira et al. 2014; Filgueira et al. 2015)

A similar spatial model specific to Antigonish Harbour is in progress as part of my research but it not yet fully developed. Instead, a simpler model based on more accessible calculations is employed herein. This may be viewed as a screening model which would indicate whether there is concern that the system is close to carrying capacity. The screening model is calculated as an index, comparing the volume of water filtered daily by oyster culture compared to the volume of water renewed by tides, both terms readily estimated. The so-called Dame index has been applied numerous times in coastal waters including within our research in PEI (Grant et al. 2005).

The balance of energy intake and energy demands in animals is known as bioenergetics. The bioenergetics of oysters has been studied extensively, within numerous journal publications. The eastern oyster (*Crassostrea virginica*) is distributed in North America from the Gulf of Mexico to Newfoundland and is perhaps one of the best known invertebrate species. In laboratory experiments, oysters are placed in tanks with known concentrations of particles and allowed to feed. The reduction of particles can be associated with the water volume in which particles are suspended and used to calculate a clearance rate (volume cleared of particles) expressed in litres per hour.

Similarly, the tidal height of an estuary and its depth can be used to estimate what is known as the tidal prism, or volume of water exchanged by the tide per day. These equations are formally expressed in Grant et al. 2005. The calculations may be summarized as follows for Antigonish Harbour.

The filtration rate of a single adult oyster (ready for harvest, 60mm length) would be approximately 2.5 litres per hour or 60 litres per day. The maximum estimated oyster stocking in the proposed lease is 3,000,000 oysters. Based on the clearance rate, this number of oysters could filter 18 million litres per day equivalent to 180,000 cubic meters of water per day. Using a tidal volume of 15 million cubic meters for Antigonish Harbour (Gregory et al. 1993), the time required for filtration of the entire harbour volume by the proposed oyster leases would be 83 days. In comparison, the tidal prism renewal time of the harbour is 0.76 days. The tides will renew harbour water 109 times faster than oysters can deplete it of phytoplankton. Expressed another way, the oysters can filter only 1.2% of the harbour volume per day. It is well known that oyster filtration is subject to different temperatures and other conditions, but even doubling the clearance rate would not affect the conclusion. Is 1.2% significant? The variation in a cubic meter of water with tides and over small distance (meters) would regularly be more than 1.2%. This degree of variation is 'noise' and could never be detected in a sampling program. It is clear that at the proposed level of oyster culture in Antigonish Harbour, there will not be significant drawdown of phytoplankton.

**References**

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Filgueira R, Grant J, Stuart R, Brown MS 2013. Ecosystem modelling for ecosystem-based management of bivalve aquaculture sites in data-poor environments. Aquaculture Environment Interactions 4:117-133.

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Weitzman J, Filgueira R, Grant J. 2021. Development of best practices for more holistic assessments of carrying capacity of aquaculture. Journal of Environmental Management 287:112278