Honorable Commissioner Keliher

Department of Marine Resources

21 State Street

Augusta ME 04333

RECEIVED
JUL 7 5 2016
Maine Department of Marine Resources

RE: Bar Harbor Oyster Co. Proposed Oyster Aquaculture site near Hancock County/Bar Harbor Airport.

Dear Commissioner Keliher,

The Aircraft Owners and Pilots Association (AOPA) is the world's largest aviation organization representing 350,000 pilots, aircraft owners, and aviation enthusiasts, of which over 1,500 are residents of the State of Maine. AOPA is committed to ensuring the safety, continued viability, and development of airports across the United States. We want to go on the record as objecting to the new application made by Bar Harbor Oyster Company to install aquaculture activity at the proposed location near the Hancock County/Bar Harbor Airport.

The Federal Aviation Administration (FAA) guidance for Hazardous Wildlife Attractants On or Near Airports, Advisory Circular 150/5200-33B recommends that there be no aquaculture within five miles of an airport and that anything less than two miles constitutes a significant threat to aircraft. As the proposed placement of both tracts would exist under the base leg of the traffic pattern into Runway 17 – 35 of the Hancock County (BHB) Airport, less than 1.2 nm from the runway threshold, we strongly object to the proposed Oyster farm as it presents a serious threat to lives of residents, pilots and passengers and constitutes a distinct compromise on aviation safety.

EXHIBIT
DMR
8
Comment Letters.

In June of 2015, we objected to the permit issued by DMR (#BHBGC4) to Acadia Sea Farms is pursuant to US Army Corp of Engineers (ACOE) permit #NAE-2010-00282. However, the permit did provide caveats which incorporated certain special conditions resulting from coordination with the FAA, including:

1 Prior to installation of any structures, the permittee, shall conduct a study to determine a baseline estimate of the number of seabirds likely to be found within the projected area. Copies of this study shall be submitted to the appropriate personnel of the FAA New England Region Office.

2 The permittee shall contact the ACOE, Maine Project Office and appropriate FAA Office at least two weeks prior to the installation of associated structures.

3 The permittee shall conduct post-installation seabird monitoring studies utilizing the same methodology as was used for the pre-installation seabird monitoring study at the authorized project site for three years.

4 The permittee shall take all available and practicable steps to discourage the attraction of seabirds to the aquaculture facility.

5 If, based on review of the quarterly post-installation studies, the Corps, in consultation with the FAA, determines that congregating seabirds attracted to the aquaculture facility present an aviation safety risk, this permit may be modified, suspended, or revoked in accordance with 33.CFR 325.7.

While these conditions serve as an attempt by the ACOE to mitigate potential safety impacts resulting from the proposed Oyster Farm, we oppose any permitting of any aquaculture site within 2 nm of a public use airport to constitute *known risk*, pursuant to FAA AC 150/5200-33B. Furthermore, Condition #3 of the provisional approval stipulates that Acadia Sea Farms conduct post-installation seabird monitoring studies for a period of no less than three years prior to any additional installation approvals. Given that the FAA agreed to this study in light of a lack of data confirming oyster farms are not wildlife attractants, we *object to the approval* of any additional aquaculture sites within 2 nm of the airport until the

study is completed and results are thoroughly vetted through the FAA and made public.

Please consider AOPA a resource and an ally in all efforts to promote, preserve, and protect the unique economic engine and transportation asset that is the Hancock County (BHB) Airport. Our Government Affairs offices are available to assist at any time and may be reached at 202/737-7950.

Sincerely,

Dawn R. H. Veatch

AOPA Gov't Affairs

Senior Director, Airport and State Advocacy

Dawn Veatch
AOPA, Gov't Affairs
Senior Director, Airport and State Advocacy

+1.678.230.9429

Burke, Cindy L

From: Perry, John
Sent: Tuesday, June 30, 2015 4:12 PM
To: Burke, Cindy L; Robinson, Diantha
Subject: RE: Application of Bar Harbor Oyster Co., LLC for a standard lease

Categories: To Do

Hi Cindy,

Portion of this proposed facility appears to be within a mapped Tidal Waterfowl and Wading Bird Habitat. We recommend that the siting of the project not intersect with any mud flats.

Thank you,

John

John Perry
Environmental Review Coordinator
Maine Department of Inland Fisheries and Wildlife
284 State Street, 41 SHS
Augusta, Maine 04333-0041
Tel (207) 287-5254; Cell (207) 446-5145
Fax (207) 287-6395
www.mefishwildlife.com

Correspondence to and from this office is considered a public record and may be subject to a request under the Maine Freedom of Access Act. Information that you wish to keep confidential should not be included in email correspondence.

From: Burke, Cindy L
Sent: Friday, June 05, 2015 3:46 PM
To: Perry, John; Libby, David A; DiBello, Carol; Kelly, John; Kanwit, Kohl; Sirois, Alison; Neal, LeeAnn NAE; Carroll, Jay; Burr, Gregory; bhhmaster@barharbormaine.gov
Subject: Application of Bar Harbor Oyster Co., LLC for a standard lease located east of Israel Point, west of Thomas Island, Mt. Desert Narrows, Thomas Bay, Bar Harbor

Attached are a Request for Review and Comment and an application for a standard lease as referenced above.

Please contact me if you have any questions.

Thank you.

Cindy L. Burke, Paralegal Assistant
Maine Department of Marine Resources
21 State House Station
Augusta, ME 04333
(207) 624-6567
cindy.l.burke@maine.gov

RECEIVED
JUL 15 2016
Maine Department of Marine Resources

COUNTY OF HANCOCK
Commissioners' Office
50 State Street, Suite 7
Ellsworth, Maine 04605

Commissioners:
Steven E. Joy, District I
Percy L. Brown Jr., District II
Antonio Blasi, District III

Scott A. Adkins
County Administrator

July 12, 2016

Maine Department of Marine Resources
ATTN: Aquaculture Hearing Officer
21 State House Station
Augusta, ME 04333-0021

RE: Bar Harbor Oyster Co.,LLC application for a 24.5 acre suspended aquaculture lease located 0.8 miles SSE of the Hancock County – Bar Harbor Airport

To whom it may concern,

We are writing to express our opposition to a proposed 24.5 acre suspended aquaculture lease to be located less than one mile SSE of the Hancock County – Bar Harbor Airport.

Floating aquaculture gear is a known attractant to a wide variety of birds, which are a wildlife hazard to aircraft. The proposed lease site is located directly underneath the traffic pattern for runway 35. It is important to note that aircraft flying in the traffic pattern for RYW 35 are descending through approximately 400 or 500' AGL (above ground level) while they over fly the area where the lease is being proposed on approach to runway 35. The FAA recommends a distance of five (5) statute miles between the farthest edge of the airport's AOA and the hazardous wildlife attractant if the attractant could cause hazardous wildlife movement into or across the approach or departure airspace. Please see figure 1.

In the interest of public safety, aviation safety, property protection, and in accordance with FAA Advisory Circular 150/5200-33B, the Hancock County Commissioners and the Hancock County – Bar Harbor Airport are opposed to the project referenced above.

If the Department of Marine Resources chooses to issue a lease regardless of the objection from the County of Hancock, then at the very least, the County is requesting that the applicant be required to:
1. Install anti-perching devices on both the tops and the undersides of the floating OysterGro cages in order to reduce the attractiveness of the site to birds.
2. Remove, Collect and Dispose of all significant amounts of bio-fouling material (i.e. more than a layer of slime) from the OysterGro cages and discard it off-site at a land-based compost facility.

Sincerely,

Steven E. Joy
County Commissioner

Percy L. Brown
County Commissioner

Antonio Blasi
County Commissioner

Figure 1

Note: The green line represents the traffic pattern for Runway 35. The red lines show the location of the proposed lease site between Israel point and Thomas Island.

Burke, Cindy L

From: Ryan Swanson ~ Pemetic Purveyors with RE/MAX Hills & Harbors <ryanswanson@remax.net>
Sent: Friday, July 15, 2016 4:01 PM
To: Dean, Hannah; Burke, Cindy L
Subject: Public Comment for aquaculture lease located east of Israel Point and west of Thomas Island, Mt. Desert Narrows, Bar Harbor, Maine

Categories: To Do

Dear Ms. Dean & Ms. Burke,

Please include my comments in your file for the application submitted by Bar Harbor Oyster Co., LLC for an aquaculture lease located east of Israel Point and west of Thomas Island, Mt. Desert Narrows, Bar Harbor, Maine.

I strongly oppose any aquaculture lease granting that is located within the FAA recommended safety distance guidelines for airport operations. The above aquaculture lease application you recently received is well within the safety distance guidelines that FAA recommends **should not** have existing aquaculture production. Bird strike is a real & dangerous threat to safety and without doubt will increase in potential risk with every aquaculture lease that is granted near an airport. A single corporation profiting at the risk of death or injury to self and property for anyone flying into/out of Bar Harbor - Hancock County Airport (BHB), or even just being under the flight path, is unacceptable.

Beyond the obvious, common sense reasoning that risk of death or injury by airplane bird strike makes the granting of aquaculture leases near an airport a seemingly easy decision to deny, there is an immense economical risk that comes with the granting of aquaculture leases near BHB: when a plane goes down or lands with issue because of bird strike, this news will spread fast and ridership at BHB will plummet. This is not something that our local economy needs, again and specifically, solely for the profit of a single corporation.

Additionally, the proposed aquaculture lease will have gear in view from many points within Acadia National Park. Establishing a precedent that it is OK to place industrial marine factories (in essence what these aquaculture operations are) at the foot of and in view from one of the most treasured National Parks in our country, makes no sense at all. I sincerely hope that DMR and other lease granting powers that be will not be blinded by potential for short term gain and by effect, mar what has taken a century and counting to preserve and protect.

When a bird strike event happens, which is inevitable ~ only a matter of time once aquaculture leases within the airport safety zone commence, the public record will reflect countless citizens, organizations, town & county officials and educated professionals advising DMR to realize this danger and deny certain aquaculture lease applications because of it. Please keep this in mind. Aquaculture has a bright & promising future as a viable sector of Maine's overall economy, but only if conducted in a thoughtful and sustainable manner.

Thank you kindly for your consideration and inclusion of my remarks in the public comment record for this lease application.

Sincerely,

Ryan Swanson

Ryan Swanson, Broker
Certified Luxury Home Marketing Specialist
Accredited Home Staging Specialist
GREEN, Designee
Certified Residential Specialist
Graduate of the REALTOR Institute
Accredited Buyer Representative

Pemetic Purveyors ~ Finer Real Estate Services
RE/MAX Hills & Harbors Realty
409 High Street, Suite B
Ellsworth, ME 04605
Phone (office & cellular): 207.667.SELL
Email: RyanSwanson@remax.net

TOWN OF TRENTON

RECEIVED
JUL 18 2016
Maine Department of Marine Resources

July 13, 2016

Maine Department of Marine Resources
ATTN: Aquaculture Hearing Officer
21 State House Station
Augusta, ME 04333-0021

RE: Application of Bar Harbor Oyster Co., LLC

Dear Aquaculture Hearing Officer:

On behalf of the Trenton Board of Selectmen, I wish to register our unanimous opposition to the grant of an aquaculture lease at the site specified, "east of Israel Point and west of Thomas Island, Mt. Desert Narrows."

Our basis for this opposition is our firm belief that placing this enterprise at that location will jeopardize the safety and property of Trenton residents. This location is within five miles of the Hancock County Bar Harbor Airport, and per FAA Advisory Circular 150/5200-33B, can be expected to increase risk to flights arriving and departing the airport due to bird strikes. OysterGro cages are known bird attractants.

Recent history has shown, with an oyster aquaculture lease already granted in nearby Goose Cove, that human lives and airport safety are not top priorities when balanced against profit and a mission to make aquaculture a viable Maine industry. By its own admission, DMR does not assume to pass judgement for FAA on air safety. However, DMR may choose to use common sense and not blind itself to the increased risk within close proximity of the airport. If this new lease is issued, Hancock County Bar Harbor Airport will be nearly surrounded with significant aquaculture leases, having the potential to attract enough birds into the flight paths that safe flight becomes a serious gamble. We strongly oppose this aquaculture lease.

59 Oak Point Road, Trenton, Maine 04605 ▪ (207) 667-7207
E-mail: townoffice@trentonme.com ▪ Web: www.trentonme.com

We ask that a representative of the Trenton Board of Selectmen be permitted to speak at the public hearing in Bar Harbor on July 28th.

Sincerely,

Fred Ehrlenbach, Chairman
Trenton Board of Selectmen

Cc: County of Hancock
Commissioners' Office
50 State Street, Suite 7
Ellsworth, ME 04605

Department of the Army
US Army Corps of Engineers
ATTN: COL Christopher A. Barron
District Engineer
696 Virginia Road
Concord, MA 01742-2751

Town of Bar Harbor
ATTN: Cornell F. Knight
Town Manager
93 Cottage Street
Bar Harbor, ME 04609

TOWN OF TRENTON

RECEIVED
JUL 18 2016
Maine Department of Marine Resources

July 13, 2016

Department of the Army
US Army Corps of Engineers
ATTN: COL Christopher A. Barron
District Engineer
696 Virginia Road
Concord, MA 01742-2751

RE: Oyster Aquaculture Application, Israel Point & Thomas Island, Mt. Desert Narrows, Bar Harbor, ME

Dear COL Barron:

On July 28th, the Maine State Department of Marine Resources (DMR) will hold a public hearing on the application of the Bar Harbor Oyster Co., LLC, to place a 24.5-acre oyster aquaculture lease at the above noted location. This is within a five-mile radius of the Hancock County Bar Harbor Airport, and per Federal Aviation Administration (FAA) Advisory Circular 150/5200-33B is therefore considered to be a risk to flights arriving and departing due to the increased attraction of hazardous wildlife, particularly birds. Experience has shown that DMR will almost certainly seek clarification from FAA of this risk to air traffic through the US Army Corps of Engineers.

This airport is in the Town of Trenton, and the Trenton Board of Selectmen has unanimously decided to oppose this aquaculture effort based on our concerns for the safety of our residents and their property. Knowing that your agency will be included in the approval process, we request that US Army Corps of Engineers hold a public hearing on this application so that the concerns of the public may be aired and heard by all.

Thank you for your consideration and your time. We will be monitoring the progress of this application, and look forward to hearing from you when DMR turns to your agency, as we expect it will.

59 Oak Point Road, Trenton, Maine 04605 ▪ (207) 667-7207
E-mail: townoffice@trentonme.com ▪ Web: www.trentonme.com

Sincerely,

Fred Ehrlenbach, Chairman
Trenton Board of Selectmen

Cc: County of Hancock
Commissioners' Office
50 State Street, Suite 7
Ellsworth, ME 04605

Maine Department of Marine Resources
21 State House Station
Augusta, ME 04333-0021

Town of Bar Harbor
ATTN: Cornell F. Knight
Town Manager
93 Cottage Street
Bar Harbor, ME 04609

RECEIVED
JUL 21 2016
Maine Department of
Marine Resources

July 18, 2016

Maine Dept. of Marine Resources
ATTN: Aquaculture Hearing Officer
21 State House Station
Augusta, Maine
04333-0021

Dear Officer,

Although we support most Aquaculture projects, there is a right way and a wrong way to do these projects. With regard to the proposed Goose Cove and Israel Point oyster farm projects near MDI., we are opposed. While in this area of Maine it may not be possible to seed oysters into a sandy bed as they naturally occur (the method used in the highly successful Duxbury Massachusetts oyster farms for example), but oyster cages can be submerged below the water surface making them nearly invisible, and eliminating what would otherwise become an industrial oyster farm despoiling the incredible views of the area. We hope that the Army Corps of Engineers will consider everyone effected by your decisions. It is possible for the aquaculture industry to coexist along with the tourist industry, and the interests of property owners in the area. Let's protect the beauty of Mount Desert Island for everyone to enjoy for generations to come.

Sincerely,

Donna Pinto

Donna and Steve Pinto

Burke, Cindy L

From: Michael Grunze <grunze@me.com>
Sent: Saturday, July 23, 2016 5:46 PM
To: Dean, Hannah; Burke, Cindy L
Subject: RE: Bar Harbor Oyster Co.,LLC application for a 24.5 acre suspended aquaculture lease located 0.8 miles SSE of the Hancock County – Bar Harbor Airport

Dear Aquaculture Hearing Officers,
I am writing to express my opposition against the proposed 24.5 acre suspended aquaculture lease to be located less than one mile SSE of the Hancock County – Bar Harbor Airport. The reasons I am heavily against this aquaculture lease are the same why I am opposing the lease in Goose Cove: public safety and endangerment of lives and property of the residents of Trenton and passing through visitors. It is well established and recorded that floating aquaculture gear is a known attractant to a wide variety of birds, which are a wildlife hazard to aircraft. The proposed lease site is located directly underneath the traffic pattern for runway 35, so that the real danger exists that a landing or starting airplane will experience a bird strike with unforeseen consequences for the control of the airplane You should have noticed that the Trenton School is in the the traffic pattern for Runway 35. This means that all residents having children in the Trenton school could be confronted with a terrible accident.
I point out again-as in my letters written to you and newspapers when referring to the lease in Goose Cove- the abundance of various sea birds in the area flying in an altitude landing planes are seen at, and again the still unresolved liability situation if a accident happens.
I can not understand why aquaculture leases have to be located in the traffic patterns of an airport, when there is plenty nearby space for aquacultures. Not only in my opinion it is irresponsible and ignorant of public safety to grant a lease under an approach path for airplanes, considering the risks for human life and property.
Sincerely,

Michael Grunze

Dr. Michael Grunze
P.O. Box 977
Mount Desert, ME 04660-0977
USA
Phone: (207) 479 3567
e-mail: grunze@me.com

Burke, Cindy L

From:	William Stockman <wsstockman@aol.com>
Sent:	Saturday, July 23, 2016 12:33 PM
To:	Dean, Hannah; Burke, Cindy L
Subject:	Public Comment re Bar Harbor Oyster Co.,LLC aquaculture lease
Attachments:	Deterring Coastal Birds from roosting.pdf; Opposition Letter to DMR (WSS).pdf

RE: Suspended Oyster aquaculture lease application by Bar Harbor Oyster Co., LLC for a 24.5 acre lease located in Mt. Desert Narrows between Israel Point and Thomas Island, Bar Harbor, Maine

July 23, 2016

Dear Aquaculture Hearing Officer and Ms. Dean & Ms. Burke,

I am writing to express my strong opposition to granting such a lease. My objection is based on well documented evidence that the type of floating gear (Oyster Gro) being proposed to be used at this site, and the methodology of flipping them to "desiccate sea growth", is known to attract sea birds.

Supporting this evidence, the DMR's own Site Review (#2015-10) conducted on 9/25/2015 shows on page 3, a picture (Image 1) of 3 cormorants, one on each of the 3 floating cages in a string, at the experimental site. The report summarizes this fact on page 16, and also reports on a small flock of gulls. Extrapolating this documented finding then, is it possible that when the lease site is fully operational with 1240 floating cages, there will be, among other birds, 1200+ cormorants below the flight path?

Two significant problems result from such attraction:

First, the oysters suspended within the cages are exposed to significant and concentrated amounts of bird fecal matter, leading to their potential contamination. In a You Tube video that I took on 9/27/2015 at the experimental site in Mt Desert Narrows https://youtu.be/FKY93V7F8TI, not only were there cormorants perching on the floating cages as per above, again in a near 1 for 1 ratio, there was clear evidence of numerous fecal matter deposits on the floats and cages below and water immediately surrounding them. Also attached to this letter, is a thorough, well documented Canadian study which has innumerable references to seabirds being attracted to such floating cages, particularly when they are flipped, and also confirming the fecal contamination problems that are known to result.

Second, and of even greater concern, is the fact that by attracting birds to the lease area, which is directly under a flight path to Bar Harbor Regional Airport, and within 10,000 of same, the proposed operation will create an unnecessary air traffic safety risk, to the flying public and those who work, travel and live in proximity to the airport.

While the DMR has taken the position that it has no responsibility for Air Safety, by allowing a known bird attractant to be placed within proximity to this airport as is proposed, the DMR will be complicit in exacerbating risks to the public at large, without having weighed the adequacy of preventive methods to avert such risks, including specific details of the equipment used and the exact operational practices employed, which the DMR does have explicit responsibility for. In addition, unless some alternative public process is established, through which the air safety aspects of this application are evaluated with equal thoroughness and openness as the DMR applies to overseeing its "mandated criteria", this matter of grave public concern to Maine residents and visitors, will possibly again be dealt with "behind closed doors" by the two Federal Agencies responsible for the Air Safety aspects of this lease.

In summary, I urge you to deny approval of the proposed lease. I also request that the DMR advocate for the establishment of a **publicly open process** by the US Army Corps of Engineers and FAA to deal with permitting the use of suspended aquaculture at this location.

Sincerely,

William S. Stockman
580 Oak Point Rd.
Trenton, Maine, 04605

2 attachments

EXHIBIT B

Aquacultural Engineering 40 (2009) 87–94

Contents lists available at ScienceDirect

Aquacultural Engineering

journal homepage: www.elsevier.com/locate/aqua-online

Deterring coastal birds from roosting on oyster culture gear in eastern New Brunswick, Canada

L.A. Comeau [a,*], P. St-Onge [a], F. Pernet [b,1], L. Lanteigne [c]

[a] Fisheries and Oceans Canada, Gulf Fisheries Centre, P.O. Box 5030, Moncton, New Brunswick, Canada E1C 9B6
[b] Institut de Recherche sur les Zones Côtières, 232B rue de l'Église, Shippagan, New Brunswick, Canada E8S 1J2
[c] P.O. Box 3308, Tracadie-Sheila, New Brunswick, Canada E1X 1G5

ARTICLE INFO

Article history:
Received 20 August 2008
Accepted 17 November 2008

Keywords:
Crassostrea virginica
Oyster
Aquaculture
Phalacrocorax auritus
Cormorant
Roosting
Birds

ABSTRACT

An ornithological survey was conducted along the eastern coastline of New Brunswick, Canada, where oysters are cultivated in suspension using PVC bags and wire-mesh cages. Thirteen bird species and a variety of unidentified shorebirds were observed roosting on the floating oyster gear. The double-crested cormorant (*Phalacrocorax auritus*) was the most common species observed (47.6% of all counts), closely followed by herring gulls (*Larus argentatus*) and common terns (*Sterna hirundo*) at 18.7% and 13.0%, respectively. Birds were densely aggregated where few cages or bags had been deployed. A gear-type effect was also detected: birds were more abundant on floating cages (mean = 47.9/100 m^2 of exposed area, S.E. = 5.8) than on floating bags (mean = 32.8/100 m^2, S.E. = 1.9). The survey was followed by two experiments designed to test the effects of gear modifications on bird abundance and diversity. For bags, results indicated that shallow immersion (~6 cm below surface) and floater instability were effective deterrents to *P. auritus*, reducing its abundance by a 37-fold factor. For wire-mesh cages, a dented triangular structure mounted on top of floaters was a harassing physical barrier to roosting behaviour, consequently reducing bird abundances to null (or near null) values.

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1. Introduction

Communal roosting is a common behaviour in several species of social animals, including coastal birds (McGowan et al., 2006). This behaviour has evolved independently numerous times (Beauchamp, 1999; McGowan et al., 2006) and is thought to positively impact several species of seabirds (Roycroft et al., 2007) by enhancing the sharing of information (Ward and Zahavi, 1973; Ydenberg and Prins, 1984; Dall, 2002) and by promoting recruitment (Richner and Heeb, 1996; Dall, 2002). Roosting behaviour can also increase foraging efficiency, reduce predation risk and minimize thermoregulatory costs (Ydenberg and Prins, 1984; Beauchamp, 1999; McGowan et al., 2006). The behaviour has been studied extensively from an ecological perspective, providing a better understanding of roost choices (Luis et al., 2001; Rogers, 2003; Rogers et al., 2006), species distribution (King, 1996; Bugoni and Vooren, 2005; Dittman et al., 2005) and hierarchical dominance in roosting populations.

From an aquaculture perspective, however, communal roosting is considered a nuisance. Birds predate on cultured fish stocks (Jenkins and Smith, 1998; Dorr et al., 2004; King, 2005), and their presence also raises other concerns, such as water contamination by faecal coliforms (Kirschner et al., 2004; Kuntz et al., 2004; Bucio et al., 2006), propagation of pathogenic agents (Flowers et al., 2004; Overstreet and Curran, 2004; Mitchell et al., 2005), and organic enrichment of sediments (Powell et al., 1991). Several bird-deterring techniques have been suggested in the literature (see review by Mott and Boyd, 1995). These methods include scaring effigies (Stickley et al., 1995; Seamans, 2004), repelling chemicals (Cotterill et al., 2004; McWilliam and Cheke, 2004; Harpaz and Clark, 2006), fencing and netting (Mott and Flynt, 1995; Nemtzov and Olsvig-Whittaker, 2003), harassment devices (Mott et al., 1998; Tobin et al., 2002), and the more-drastic solution of hunting (Bechard and Marquez-Reyes, 2003; McWilliam and Cheke, 2004).

In New Brunswick, Canada, oyster (*Crassostrea virginica*) farming is carried out in approximately 15 embayments (Fig. 1). Suspended culture, in which oysters are held inside floating PVC bags or floating cages (Fig. 2), is the predominant farming technique. In winter floaters are removed to lower stocks onto the bottom where they are protected from the thick ice. At other times, however, stocks are suspended at the surface in a relatively

* Corresponding author.
E-mail address: luc.comeau@dfo-mpo.gc.ca (L.A. Comeau).
[1] Present address: IFREMER, Avenue Jean Monnet, 34200 Sète, France.

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doi:10.1016/j.aquaeng.2008.11.003

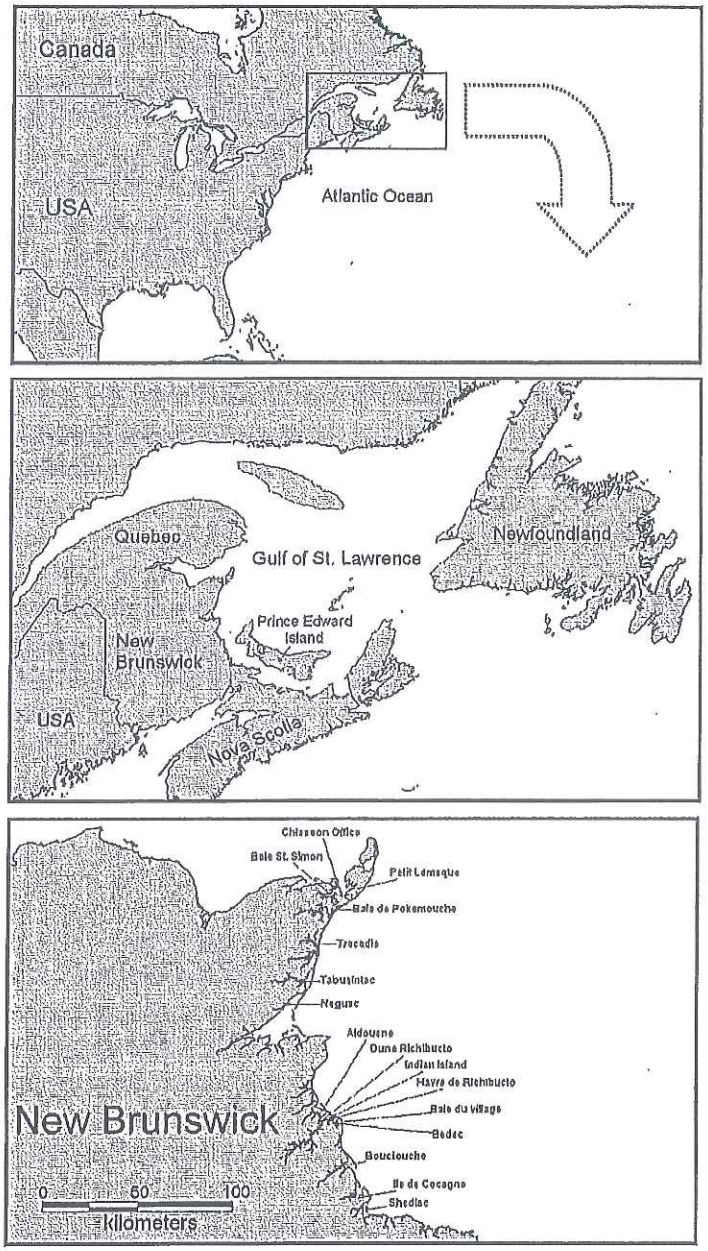

Fig. 1. Map of study area showing oyster farming sites in New Brunswick.

warm and phytoplankton-abundant environment, thereby enhancing shell growth and shortening the production cycle. When at the surface, stocks are easily accessible to growers for harvesting and grading procedures; moreover, the suspended bags or cages can be flipped and temporarily exposed to air, thereby desiccating biofoulers. The entire technique for suspending and flipping bags and cages has been developed in New Brunswick in the late 1990s.

Floating gear, on the other hand, provides substantial roosting areas for coastal birds. In 2004, Canadian food safety and fisheries agencies have requested that all oysters contained in floating bags or cages be depurated prior to harvest. The precautionary depuration procedure requires the transfer of suspended stocks onto the bottom 30 days prior to harvest (14 days if stocks are subsequently tested for coliforms as required by the Canadian Shellfish Sanitation Program, 2005). The new regulation increases both labour and time needed to complete the production cycle. Consequently, there is a growing interest in developing new floating gear designs that could prevent birds from roosting in oyster farms. The underlying rational is that effective bird-deterring designs would ultimately be exempted from the regulation pertaining to depuration.

In this paper, we begin by reporting results from an ornithological survey conducted in NB oyster farms. We identify bird species and report on their abundance in relation to current

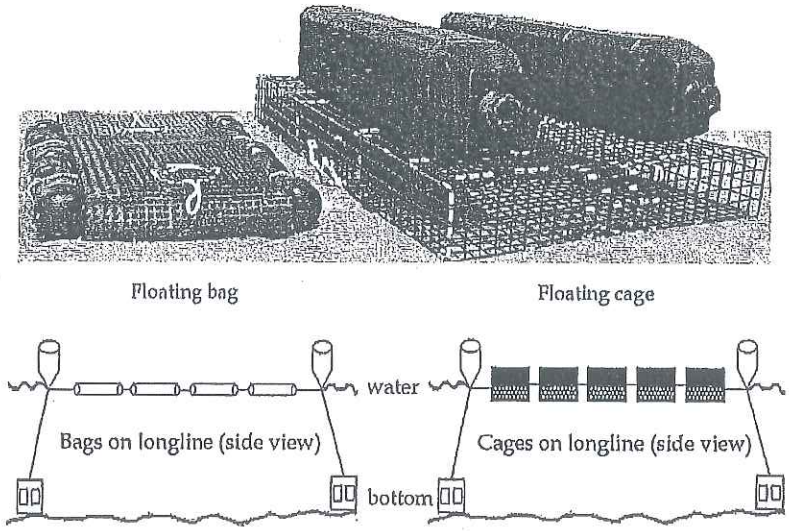

Fig. 2. Floating gear types currently present in New Brunswick oyster farms. The trademark for the floating cage is OysterGro®, manufactured by Bouctouche Bay Industries Ltd. in New Brunswick.

floating gear designs. The survey was followed by two field experiments examining the effects of gear modifications on bird abundance and diversity.

2. Methods

2.1. Survey

In September and October 2005, 15 embayments along the eastern coastline of New Brunswick were visited. The location of each embayment is identified in Fig. 1. A total of 22,600 floating bags and 4609 floating cages were examined for the presence of birds. Bird observations were carried out either from land or from a kayak using binoculars and a spotting scope. Only birds perching on oyster gear and any associated buoys were identified and counted. Bird counts reflect the maximum number of individuals seen at any one time during a disturbance-free period of 15 min. All counts were carried out between 10 a.m. and 4 p.m. A subsequent analysis indicated that the time of day had no significant effect on bird counts.

It is also important to note that the surface areas available for roosting differ according to gear type. For a floating bag, which has two small floaters and one PVC bag that are exposed and available for roosting, this area is approximately 0.35 m^2. For a floating cage, the available roosting area provided by the two large floaters is 0.45 m^2; the wire-mesh cage itself is too deep—12 cm below surface—to provide a roosting surface. In keeping with this information, counts were standardized as the number of birds per 100 m^2 of available (exposed) roosting area.

2.2. Floating bag experiment

In 2006, three different types of floating bags were deployed within an experimental setting. The first type consisted of standard bags (S) with lateral floaters typical of those in current use by most growers (Fig. 3a). For the second type, the S configuration was modified by positioning the two side floaters onto the top of the bag, thereby allowing the bag to sink approximately 3 cm below the water surface (Fig. 3b). While the two floaters remain a potential perching platform for birds, the area they offer to birds is less than 20% that of the unmodified bag. This modification was termed M1. In a second modification (M2), the S configuration was modified by positioning the two side floaters on top of the bag, but the bag itself was lowered approximately 6 cm below the surface using loose rope (Fig. 3c). The loose rope between the floaters and the bag rendered the floaters unstable.

The experimental bags were deployed in three embayments: Chiasson Office, Néguac, and Richibucto (see Fig. 1). At each of these sites, three longlines were deployed equidistantly (6.1 m) as illustrated in Fig. 4. Each longline held 11 floating bags per type (S, M1 and M2), which were dispersed in groups of three bags (except at the end of the longline where space was lacking and where grouping was limited to two bags). Details regarding bag layout are of no consequence since the entire longline itself was considered the statistical unit. For that reason, a single bird count (per bag type) was performed for each experimental longline. Bird counts represent the maximum number of individuals seen at any one time during a 1-h period. Counts were standardized to the number of birds per 100 bags. Species richness represents the number of different species observed during the count period. All observations were carried out at bi-monthly intervals between August 28 and November 7, 2006.

Data were partitioned into five 2-week intervals. Factors for each variable were analysed using a complete randomized block design with repeated measures according to gear type (fixed between-subjects factor with three levels [M1, M2 and S]), sites (fixed between-subjects factor with three levels [Chiasson Office, Néguac, and Richibucto]), sampling time (random factor with five levels of repeated measurements) and all their mutual interactions. Mauchly's test ($\alpha = 0.05$) was used to assess whether datasets conformed to the sphericity assumption required for a repeated measure analysis. When the sphericity assumption was not met, the degrees of freedom were adjusted accordingly using the Huynh–Feldt correction. Significant differences between all possible combinations of sample means for gear type were also assessed using Tukey's HSD test ($\alpha = 0.05$). All analyses were performed with SPSS 10.0 for Windows® (SPSS Inc., Chicago, IL, USA).

2.3. Floating cage experiment

Bouctouche Bay Industries Ltd. has developed the AntiCormo (AC), a bird-deterrent structure that can be fitted easily onto

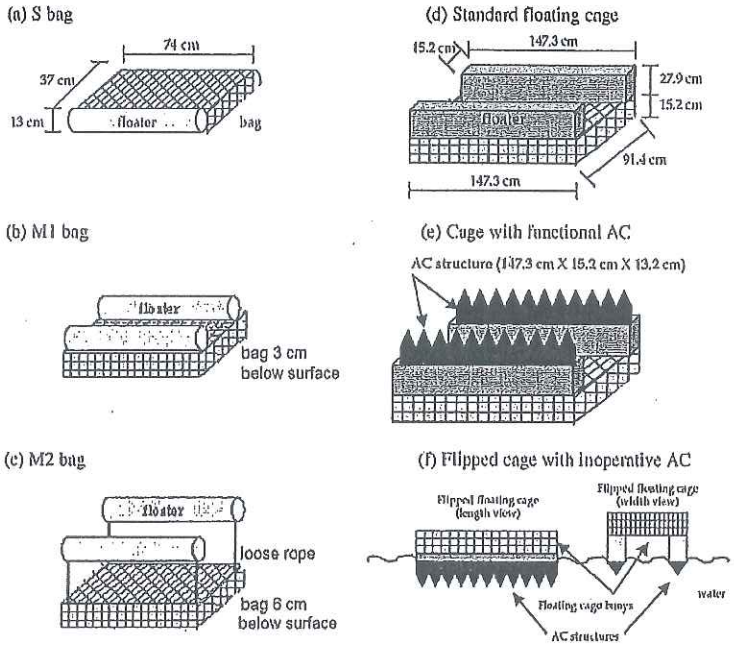

Fig. 3. Floating gear prototypes tested in the present study.

floating cages as illustrated in Fig. 3e. Taking into account the ability of birds to adapt over time, our goal in this experiment was to assess the effectiveness of the AC in deterring birds over an extended period. Our experimental approach was based on the full conversion of two farms and monitoring of bird abundance over an 18-week period (July 1 to November 3, 2007). One farm was located in Shediac Bay and contained a total of 140 floating cages (14 longlines of 10 cages); the second farm was located in Bouctouche Bay and held 100 cages (10 longlines of 10 cages). The two farms were selected because they were isolated, with the closest commercial aquaculture activities located at a distance of 5–10 km. The presence of bird colonies near the experimental farms was verified using two approaches: (1) by removing the AC devices at the start and completion of the experiment, and (2) by occasionally flipping cages and rendering the AC non-functional (i.e., underwater, as illustrated in Fig. 3f).

Once a week, bird counts were performed from land using a spotting scope. Counts were limited to four randomly selected longlines (the statistical unit). The count period consisted of four consecutive 15-min intervals. Data corresponding to the interval with the maximum number of individuals of the same species were kept for analysis. Descriptive statistics, including the standardized bird abundance per 100 floating cages, were computed for each experimental site.

3. Results

3.1. Survey

Thirteen bird species and a variety of unidentified shorebirds were observed roosting on floating oyster gear (Table 1). The most common species was the double-crested cormorant (*Phalacrocorax auritus*), representing almost half (47.6%) of all counts. Behaviourally, *P. auritus* was observed perching and preening, as well as drying its wings. Herring gulls (*Larus argentatus*) and common terns (*Sterna hirundo*) were also often spotted (18.7% and 13.0% of all counts).

Bird abundance was inversely correlated with the total roosting area made available by the floating gear (Fig. 5). The highest abundances, indicating a high degree of aggregation, were recorded at sites containing relatively few bags or cages. In keeping with these results, bird abundances were normalized to remove the effect of available roosting area. Following this correction, we found that birds were more abundant on floating

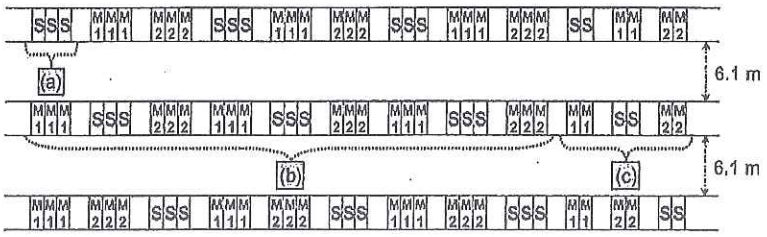

Fig. 4. Example layout of three experimental longlines holding three types of floating oyster bags: standard (S), first modification (M1) and second modification (M2). (a) Group of three bags of the same gear type. (b) Nine groups of three bags laid out in a random order. (c) End of experimental culture line with three groups of two bags laid out in a random order.

Table 1
Bird species surveyed at commercial oyster farming sites in New Brunswick.

Common name	Latin name	Total counts	% Total count
Double-crested cormorant	*Phalacrocorax auritus*	1588	47.6
Herring gull	*Larus argentatus*	624	18.7
Common tern	*Sterna hirundo*	435	13.0
Black-bellied plover	*Pluvialis squatarola*	160	4.8
Dunlin	*Caldris alpina*	146	4.4
Greater black-backed gull	*Larus marinus*	117	3.5
Immature gull	*Larus* spp.	70	2.1
Bonaparte's gull	*Larus philadelphia*	52	1.6
Ringed-billed gull	*Larus delawarensis*	51	1.5
Shorebirds spp.	*Caldris* spp.	28	0.8
Red-breasted merganser	*Mergus serrator*	23	0.7
Black duck	*Anas rubripes*	9	0.3
Greater yellowlegs	*Tringa melanoleuca*	8	0.2
Great blue heron	*Ardea herodias*	6	0.2
Lesser yellowlegs	*Tringa flavipes*	1	0.0
All species		3318	100.0

cages (mean = 47.9/100 m^2, S.E. = 5.8) than on floating bags (mean = 32.8/100 m^2, S.E. = 1.9) ($P < 0.001$, Mann–Whitney).

3.2. Floating bag experiment

Table 2 summarizes the outcome of the floating bag experiment. Gear type, which is the key factor of interest in the present investigation, was the only factor that yielded a significant effect on species richness in the main effects category. Moreover, gear type showed no interactions with sampling time, indicating that the effect on species richness was consistent through time. Similar effects were detected on bird abundance. Gear type exerted a significant influence on abundance and there was no interaction between gear type and sampling time. The same outcome was obtained whether all species were grouped or *P. auritus* was analysed separately. By contrast, no gear effect was found when analysing other species (e.g., *Larus* spp.) separately.

Fig. 6 shows mean species richness (panel A) and abundance (panel B) in relation to gear type. Post hoc analyses (Tukey's HSD) indicated that gear-type effects were attributable to differences between S and M2 bags. On average, species richness for S bags was approximately seven times higher than for M2 bags. A total of nine species were seen roosting on S bags throughout the duration of the experiment compared to only two species for M2 bags (*P. auritus* and *Larus marinus*). S bags also attracted a greater number of *P. auritus* compared to M2 bags. Average standardized abundance of *P. auritus* was approximately 37 times greater on S bags than on M2 bags.

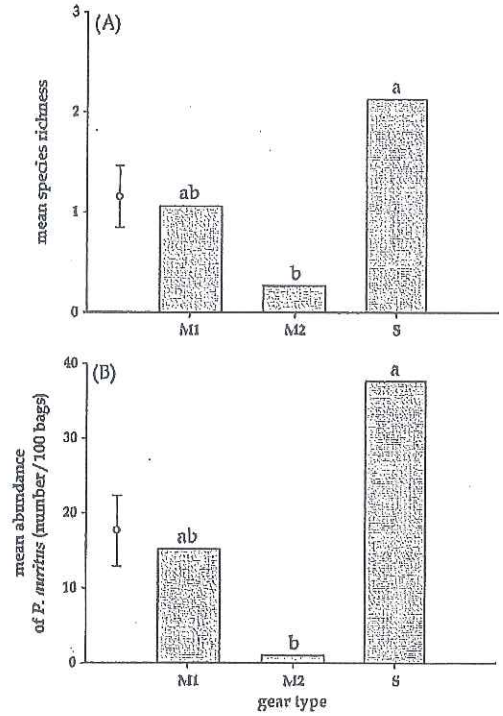

Fig. 6. Mean species richness (a) and abundance (b) of birds roosting on floating bags of type S (standard), M1 (first modification) and M2 (second modification). Means are presented with a single error bar provided by the standard model error (SME). Bars with different letters differ significantly from each other (Tukey's HSD).

3.3. Floating cage experiment

Fig. 7 shows the abundance time-series for the two experimental sites. At the Shediac site, AC structures were absent on several occasions (weeks 1–4, 15, 17 and 18); during these periods, abundance varied between 100 and nearly 500 birds per 100 floating cages. Abundance was also elevated at times when AC devices were inoperative due to the flipping of cages. Similar results were obtained at the Bouctouche site, with the exception that no birds were spotted in week 4 when the AC structures were absent. A total of 2195 individuals and 5 species (*P. auritus*, *L. argentatus*, *L. marinus*, *S. hirundo* and *Ardea herodias*) were identified at the two experimental sites; *P. auritus* was the dominant species, accounting for nearly 85% of all counts; *S. hirundo* and *L. argentatus* were also regularly spotted, with each species accounting for approximately 7% of all counts. Together these observations indicate that the two experimental sites were appropriate for testing the AC device.

Floating cages equipped with functioning AC devices attracted fewer birds. Weekly abundance estimates varied between 0 and 1.25 (S.E. = 0.72) birds per 100 floating cages at the Shediac site. During a 13-week period, only two individual birds, one *P. auritus* and one *L. argentatus*, were seen at this site. A total of 146 birds were spotted at the Bouctouche site, and weekly abundance

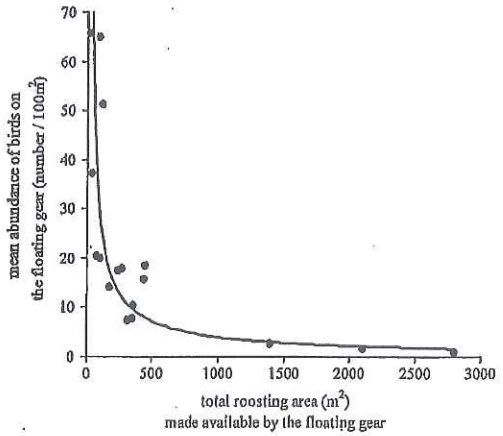

Fig. 5. Relationship between bird abundance and the roosting area made available by floating oyster gear. The solid line is a power-fit to the following function: $y = 1388.5x^{-0.8467}$ ($r^2 = 0.82$, $P < 0.001$). Data points represent the mean values of several sampling dates for individual sites.

Table 2
Summary of a complete randomized block with repeated measures carried out on four variables: species richness, abundance of all species, abundance of *P. auritus*, and abundance of *Larus* spp.

Source of variation	d.f.	SS	Adjusted d.f.[a]	MS[b]	F	P[c]
(a) Species richness						
Site (S)	2	5.91	–	2.96	2.08	0.241
Gear type (G)	1	26.31	–	13.16	9.25	0.032
Between-subjects error	4	5.69	–	1.42	–	–
Time of sampling (T)	4	1.47	–	0.37	0.82	0.534
T × G	8	0.80	–	0.10	0.22	0.981
T × S	8	6.53	–	0.82	1.82	0.148
Within-subjects error	16	7.20	–	0.45	–	–
Total	44	53.91	–	–	–	–
(b) Abundance all species						
Site (S)	2	6019.38	–	3009.69	4.38	0.098
Gear type (G)	2	14181.00	–	7090.50	10.32	0.026
Between-subjects error	4	2745.84	–	686.46	–	–
Time of sampling (T)	4	4018.77	–	1004.69	5.33	0.006
T × G	8	2549.94	–	318.74	1.69	0.176
T × S	8	4730.53	–	591.31	3.13	0.025
Within-subjects error	16	3014.79	–	188.42	–	–
Total	44	37260.25	–	–	–	–
(c) Abundance of *P. auritus*						
Site (S)	2	4150.17	–	2075.08	4.00	0.111
Gear type (G)	2	10280.67	–	5140.33	9.91	0.028
Between-subjects error	4	2074.46	–	518.61	–	–
Time of sampling (T)	4	4878.04	3.24	1503.75	3.35	0.050
T × G	8	4317.36	6.49	665.46	1.48	0.257
T × S	8	8493.23	6.49	1309.10	2.92	0.048
Within-subjects error	16	5817.84	12.98	448.37	–	–
Total	44	40011.77	–	–	–	–
(d) Abundance of *Larus* spp.						
Site (S)	2	880.13	–	440.07	1.39	0.348
Gear type (G)	2	1846.76	–	923.38	2.92	0.165
Between-subjects error	4	1264.04	–	316.01	–	–
Time of sampling (T)	4	71.36	3.37	21.17	0.58	0.654
T × G	8	76.06	6.74	11.28	0.31	0.933
T × S	8	255.65	6.74	37.92	1.05	0.444
Within-subjects error	16	489.10	13.48	36.28	–	–
Total	44	4883.10	–	–	–	–

[a] Adjusted degrees of freedom (Huynh–Feldt correction) where the sphericity assumption is not met, $\alpha = 0.05$.
[b] Computed with adjusted degrees of freedom where available.
[c] Bold font indicates significance, $\alpha = 0.05$.

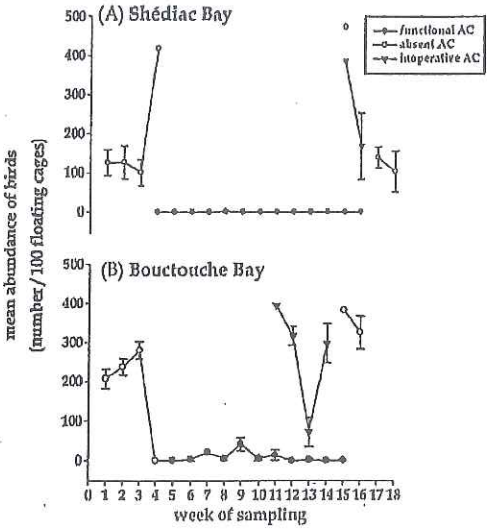

Fig. 7. Mean abundance (±S.E.) of birds roosting on experimental cages in Shediac (A) and Bouctouche (B). The time-series extends from July 1, 2007 (week 1) to November 3, 2007 (week 18).

estimates ranged from 0 to 41.9 (S.E. = 15.9) birds per 100 floating cages. There were no indications that birds progressively adapted (i.e., no increase in abundance over time) to AC devices at either site.

4. Discussion

4.1. Survey

An extensive ornithological survey indicated the presence of 13 bird species roosting on floating oyster gear along the eastern coastline of New Brunswick. Three species—*P. auritus*, *L. argentatus* and *S. hirundo*—which together were responsible for 79% of all counts, clearly dominated. These species have well-established breeding areas along the eastern coastline of New Brunswick (Erskine, 1992). They prey mainly on fish and small marine invertebrates such as zooplankton. There are previous reports on bird interference with aquaculture operations, although these studies have focused exclusively on predation of cultured stocks, such as *P. auritus* preying on farm-raised channel catfish (*Ictalurus punctatus*) in the southern United States (King, 1996). In our study, it was apparent that birds used floating oyster gear as roosting platforms.

Regarding abundances, the survey indicated that birds were densely aggregated where few culture units had been deployed (as per the relationship presented in Fig. 5). This result implies that the

bird nuisance perception is function of the farming activity level. For example, in New Brunswick, the number of floating bags within individual leases varies from approximately 100 to 12,481 units (Comeau et al., 2006). We estimate, based upon the relationship shown in Fig. 5, that the lower end of activity (100 bags) could attract approximately 24 birds over a small body of water (~700 m^2), whereas the peak activity level (12,481 bags) may attract 49 birds dispersed over a much larger body of water (150,000 m^2). In keeping with this comparison, the amount of floating gear within a culture lease is perhaps a key parameter to consider when modelling the potential risks of water contamination by birds.

Another factor that seems relevant is gear type. Our survey suggests that birds have a preference for floating cages. This result may be attributable to cage design: compared to floating bags, floating cages are relatively stable and offer a large roosting area, attributes that are compatible with the large size and gregarious nature of *P. auritus* (Hatch and Weseloh, 1999). Also, floating cages provide an elevated platform (~17 cm above the waterline) compared to floating bags (~2 cm above the waterline). After diving, *P. auritus* usually looks for an elevated spot to perch, where it can spread its wings to dry its feathers (Hatch and Weseloh, 1999).

4.2. Floating bag experiment

The goal of this experiment was to compare bird diversity and abundance in relation to three bag deployment strategies: (1) standard (S) deployment, with the top portion of bags floating above surface; (2) modified (M1) deployment, with bags completely submerged ~3 cm under the surface; and (3) modified (M2) deployment, with bags submerged ~6 cm under the surface. Significant differences in bird diversity were found only between S and M2 bags; of the nine species observed on S bags during the experiment, only two (*P. auritus* and *L. marinus*) were seen on M2 bags. Three factors likely contributed to the decrease in diversity on M2 bags: depth (6 cm) at which the bag itself was maintained, floater instability, and interactions with floating organic debris. In terms of bag depth, it is noteworthy that both *P. auritus* and *L. marinus* have long tarsi, averaging approximately 8 and 9 cm, respectively (The New Brunswick Museum); species that avoided M2 have comparatively short tarsi. An influence of depth is consistent with reports of coastal birds changing their roost location with rising tides (e.g., Luis et al., 2001; Rogers, 2003; Rosa et al., 2006). The M2 modification also increased floater instability. Our field notes indicate that the roosting time was very short (seconds) when *P. auritus* and *L. marinus* successfully landed on the M2 floaters; it was also noted that other species attempted to roost on M2 floaters but failed and immediately flew away. Lastly, S and M2 bags interacted differently with floating debris. S bags were often covered with common eelgrass (*Zostera marina*), which can be uprooted following storm events; M2 bags were generally free of this marine plant. This observation appears relevant because *S. hirundo* was occasionally seen feeding on small invertebrates entangled within *Z. marina*.

With respect to abundance, the total counts on S bags were dominated by *P. auritus* and *Larus* spp. The experiment showed that M2 bags attracted significantly fewer *P. auritus*. The reason(s) for M2 selecting against *P. auritus* cannot be determined with certainty. As indicated above, it is known that *P. auritus* has a marked preference for elevated perches where it can spread its wings to dry its feathers (Hatch and Weseloh, 1999). Floater instability and the depth of M2 bags probably prevented this behaviour. Gulls, on the other hand, do not exhibit this behaviour, which may explain why none of the experimental bag types significantly reduced the abundance of *Larus* spp.

4.2.1. Floating cages experiment

In this experiment, the effectiveness of a bird-deterrent device, the AntiCormo developed by Bouctouche Bay Industries Ltd., was evaluated at two sites over an 18-week period. The AC can be fitted onto existing floating cages as shown in Fig. 3e. In the absence of the AC device, floating cages generally attracted several birds as was expected from earlier survey results. This outcome indicates that local breeding populations, essential for the testing of the AC device, were present at the two experimental sites.

The AC device considerably reduced the number of birds roosting on floating cages at both experimental sites, with mean abundance falling from several hundred birds per 100 cages to null (or near null) values. Field notes indicate that the highest abundances at the Bouctouche site (e.g., mean of 41.9 birds/100 cages, week 9) were mainly associated with improperly installed AC devices. There were no indications that the birds adapted to properly installed AC devices. Therefore it appears that the AC was a harassing physical barrier, comparable to metal spikes or prongs commonly mounted, for example, on top of navigation buoys, park lights and gutters.

It is noteworthy that floating cages are occasionally flipped to control biofoulers as part of normal husbandry procedures. Once flipped, AC structures are submerged and the entire wire-mesh cage is exposed to air, thereby desiccating biofoulers. In our study, birds quickly resumed their roosting activities at times when cages were flipped. In New Brunswick, growers flip cages three to five times per year, and the desiccation of biofoulers normally occurs over 48 h, after which cages are returned to their normal position and the AC devices resume their full functionality. Evidently, cage flipping should be avoided some time prior to oyster harvesting. The "no-flip" period could be as short as 14 days in cases where there is follow-up testing for coliforms (Canadian Shellfish Sanitation Program, 2005).

5. Conclusion

This report presented possible mitigation measures to prevent the roosting of birds in oyster farms along the eastern coastline of New Brunswick. For floating bags, results suggested that floater instability coupled with an immersion depth of approximately 6 cm (for the bag itself) were effective deterrents to birds. Depth and floater instability were achieved simply by attaching loose ropes between floaters and bags. However, we recognize that this deployment scheme may not represent a practical option for the industry, given that bags must occasionally be flipped and exposed to air in order to control (desiccate) fouling organisms. Hence it is unlikely that the bag prototypes tested in the present investigation will be adopted by the industry. To date, no practical design has been found for floating bags, although the reported information on bird behaviour in the present report is useful for ongoing research.

For floating cages, a dented triangular structure (AC) mounted on top of each floater was an effective deterrent to birds. Moreover, from a practical perspective, the AC does not interfere with normal husbandry procedures. New floaters, commercially produced by Bouctouche Bay Industries Ltd. (New Brunswick, Canada), incorporate the AC (USA Patent No. D578,424 and Canadian Registration No. 125146).

Acknowledgements

Ève-Julie Arsenault, Tina Rousselle, and Roland Chiasson patiently identified and counted the birds; Alyre Chiasson, Rhéal Savoie, Marie-Josée Maillet, Marcel Léger, Christian Norris, Abel Noel, Sylvio Doiron, and Bettie Arsenault assisted in developing the project; Joe Caissie, Paul Savoie, Martin Mallet, and Serge Leblanc kindly provided access to the study sites. This study was funded by

the Professional Shellfish Growers Association of New Brunswick in partnership with the Department of Fisheries and Oceans of Canada (Aquaculture Collaboration Research and Development Program, project MG-06-04-003) and the New Brunswick Department of Agriculture and Aquaculture.

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Table 1
Bird species surveyed at commercial oyster farming sites in New Brunswick.

Common name	Latin name	Total counts	% Total count
Double-crested cormorant	*Phalacrocorax auritus*	1588	47.6
Herring gull	*Larus argentatus*	624	18.7
Common tern	*Sterna hirundo*	435	13.0
Black-bellied plover	*Pluvialis squatarola*	160	4.8
Dunlin	*Caldris alpina*	146	4.4
Greater black-backed gull	*Larus marinus*	117	3.5
Immature gull	*Larus* spp.	70	2.1
Bonaparte's gull	*Larus philadelphia*	52	1.6
Ringed-billed gull	*Larus delawarensis*	51	1.5
Shorebirds spp.	*Caldris* spp.	28	0.8
Red-breasted merganser	*Mergus serrator*	23	0.7
Black duck	*Anas rubripes*	9	0.3
Greater yellowlegs	*Tringa melanoleuca*	8	0.2
Great blue heron	*Ardea herodias*	6	0.2
Lesser yellowlegs	*Tringa flavipes*	1	0.0
All species		3318	100.0

cages (mean = 47.9/100 m^2, S.E. = 5.8) than on floating bags (mean = 32.8/100 m^2, S.E. = 1.9) ($P < 0.001$, Mann–Whitney).

3.2. Floating bag experiment

Table 2 summarizes the outcome of the floating bag experiment. Gear type, which is the key factor of interest in the present investigation, was the only factor that yielded a significant effect on species richness in the main effects category. Moreover, gear type showed no interactions with sampling time, indicating that the effect on species richness was consistent through time. Similar effects were detected on bird abundance. Gear type exerted a significant influence on abundance and there was no interaction between gear type and sampling time. The same outcome was obtained whether all species were grouped or *P. auritus* was analysed separately. By contrast, no gear effect was found when analysing other species (e.g., *Larus* spp.) separately.

Fig. 6 shows mean species richness (panel A) and abundance (panel B) in relation to gear type. Post hoc analyses (Tukey's HSD) indicated that gear-type effects were attributable to differences between S and M2 bags. On average, species richness for S bags was approximately seven times higher than for M2 bags. A total of nine species were seen roosting on S bags throughout the duration of the experiment compared to only two species for M2 bags (*P. auritus* and *Larus marinus*). S bags also attracted a greater number of *P. auritus* compared to M2 bags. Average standardized abundance of *P. auritus* was approximately 37 times greater on S bags than on M2 bags.

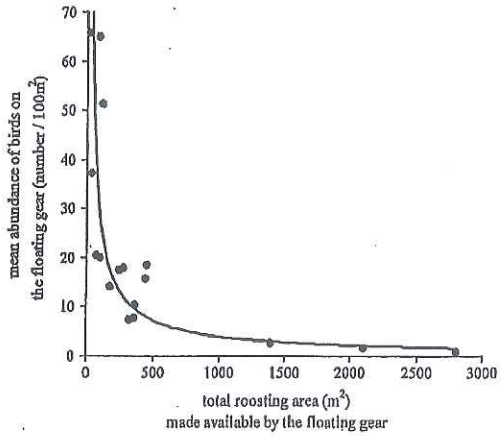

Fig. 5. Relationship between bird abundance and the roosting area made available by floating oyster gear. The solid line is a power-fit to the following function: $y = 1388.5x^{-0.8487}$ ($r^2 = 0.82$, $P < 0.001$). Data points represent the mean values of several sampling dates for individual sites.

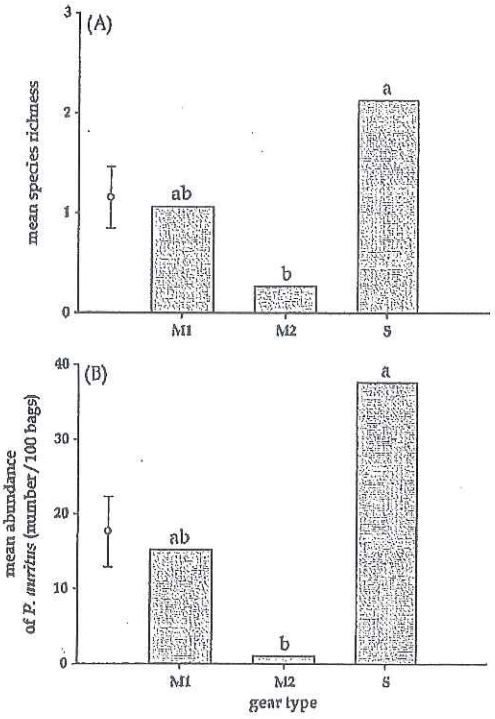

Fig. 6. Mean species richness (a) and abundance (b) of birds roosting on floating bags of type S (standard), M1 (first modification) and M2 (second modification). Means are presented with a single error bar provided by the standard model error (SME). Bars with different letters differ significantly from each other (Tukey's HSD).

3.3. Floating cage experiment

Fig. 7 shows the abundance time-series for the two experimental sites. At the Shediac site, AC structures were absent on several occasions (weeks 1–4, 15, 17 and 18); during these periods, abundance varied between 100 and nearly 500 birds per 100 floating cages. Abundance was also elevated at times when AC devices were inoperative due to the flipping of cages. Similar results were obtained at the Bouctouche site, with the exception that no birds were spotted in week 4 when the AC structures were absent. A total of 2195 individuals and 5 species (*P. auritus*, *L. argentatus*, *L. marinus*, *S. hirundo* and *Ardea herodias*) were identified at the two experimental sites; *P. auritus* was the dominant species, accounting for nearly 85% of all counts; *S. hirundo* and *L. argentatus* were also regularly spotted, with each species accounting for approximately 7% of all counts. Together these observations indicate that the two experimental sites were appropriate for testing the AC device.

Floating cages equipped with functioning AC devices attracted fewer birds. Weekly abundance estimates varied between 0 and 1.25 (S.E. = 0.72) birds per 100 floating cages at the Shediac site. During a 13-week period, only two individual birds, one *P. auritus* and one *L. argentatus*, were seen at this site. A total of 146 birds were spotted at the Bouctouche site, and weekly abundance

Table 2
Summary of a complete randomized block with repeated measures carried out on four variables: species richness, abundance of all species, abundance of *P. auritus*, and abundance of *Larus* spp.

Source of variation	d.f.	SS	Adjusted d.f.[a]	MS[b]	F	P[c]
(a) Species richness						
Site (S)	2	5.91	–	2.96	2.08	0.241
Gear type (G)	1	26.31	–	13.16	9.25	0.032
Between-subjects error	4	5.69	–	1.42	–	–
Time of sampling (T)	4	1.47	–	0.37	0.82	0.534
T × G	8	0.80	–	0.10	0.22	0.981
T × S	8	6.53	–	0.82	1.82	0.148
Within-subjects error	16	7.20	–	0.45	–	–
Total	44	53.91	–	–	–	–
(b) Abundance all species						
Site (S)	2	6019.38	–	3009.69	4.38	0.098
Gear type (G)	2	14181.00	–	7090.50	10.32	0.026
Between-subjects error	4	2745.84	–	686.46	–	–
Time of sampling (T)	4	4018.77	–	1004.69	5.33	0.006
T × G	8	2549.94	–	318.74	1.69	0.176
T × S	8	4730.53	–	591.31	3.13	0.025
Within-subjects error	16	3014.79	–	188.42	–	–
Total	44	37260.25	–	–	–	–
(c) Abundance of *P. auritus*						
Site (S)	2	4150.17	–	2075.08	4.00	0.111
Gear type (G)	2	10280.67	–	5140.33	9.91	0.028
Between-subjects error	4	2074.46	–	518.61	–	–
Time of sampling (T)	4	4878.04	3.24	1503.75	3.35	0.050
T × G	8	4317.36	6.49	665.46	1.48	0.257
T × S	8	8493.23	6.49	1309.10	2.92	0.048
Within-subjects error	16	5817.84	12.98	448.37	–	–
Total	44	40011.77	–	–	–	–
(d) Abundance of *Larus* spp.						
Site (S)	2	880.13	–	440.07	1.39	0.348
Gear type (G)	2	1846.76	–	923.38	2.92	0.165
Between-subjects error	4	1264.04	–	316.01	–	–
Time of sampling (T)	4	71.36	3.37	21.17	0.58	0.654
T × G	8	76.06	6.74	11.28	0.31	0.933
T × S	8	255.65	6.74	37.92	1.05	0.444
Within-subjects error	16	489.10	13.48	36.28	–	–
Total	44	4883.10	–	–	–	–

[a] Adjusted degrees of freedom (Huynh–Feldt correction) where the sphericity assumption is not met, $\alpha = 0.05$.
[b] Computed with adjusted degrees of freedom where available.
[c] Bold font indicates significance, $\alpha = 0.05$.

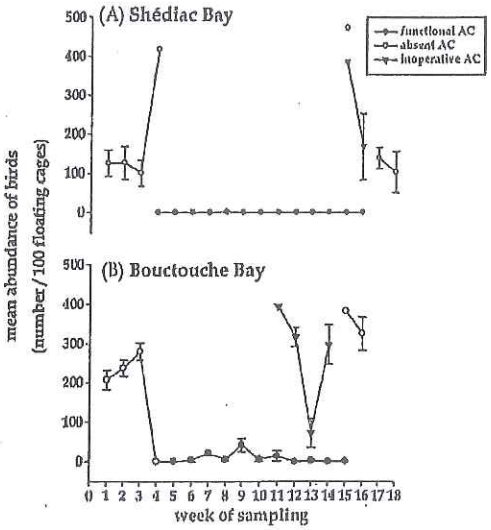

Fig. 7. Mean abundance (±S.E.) of birds roosting on experimental cages in Shediac (A) and Bouctouche (B). The time-series extends from July 1, 2007 (week 1) to November 3, 2007 (week 18).

estimates ranged from 0 to 41.9 (S.E. = 15.9) birds per 100 floating cages. There were no indications that birds progressively adapted (i.e., no increase in abundance over time) to AC devices at either site.

4. Discussion

4.1. Survey

An extensive ornithological survey indicated the presence of 13 bird species roosting on floating oyster gear along the eastern coastline of New Brunswick. Three species—*P. auritus*, *L. argentatus* and *S. hirundo*—which together were responsible for 79% of all counts, clearly dominated. These species have well-established breeding areas along the eastern coastline of New Brunswick (Erskine, 1992). They prey mainly on fish and small marine invertebrates such as zooplankton. There are previous reports on bird interference with aquaculture operations, although these studies have focused exclusively on predation of cultured stocks, such as *P. auritus* preying on farm-raised channel catfish (*Ictalurus punctatus*) in the southern United States (King, 1996). In our study, it was apparent that birds used floating oyster gear as roosting platforms.

Regarding abundances, the survey indicated that birds were densely aggregated where few culture units had been deployed (as per the relationship presented in Fig. 5). This result implies that the

bird nuisance perception is function of the farming activity level. For example, in New Brunswick, the number of floating bags within individual leases varies from approximately 100 to 12,481 units (Comeau et al., 2006). We estimate, based upon the relationship shown in Fig. 5, that the lower end of activity (100 bags) could attract approximately 24 birds over a small body of water (~700 m^2), whereas the peak activity level (12,481 bags) may attract 49 birds dispersed over a much larger body of water (150,000 m^2). In keeping with this comparison, the amount of floating gear within a culture lease is perhaps a key parameter to consider when modelling the potential risks of water contamination by birds.

Another factor that seems relevant is gear type. Our survey suggests that birds have a preference for floating cages. This result may be attributable to cage design: compared to floating bags, floating cages are relatively stable and offer a large roosting area, attributes that are compatible with the large size and gregarious nature of *P. auritus* (Hatch and Weseloh, 1999). Also, floating cages provide an elevated platform (~17 cm above the waterline) compared to floating bags (~2 cm above the waterline). After diving, *P. auritus* usually looks for an elevated spot to perch, where it can spread its wings to dry its feathers (Hatch and Weseloh, 1999).

4.2. Floating bag experiment

The goal of this experiment was to compare bird diversity and abundance in relation to three bag deployment strategies: (1) standard (S) deployment, with the top portion of bags floating above surface; (2) modified (M1) deployment, with bags completely submerged ~3 cm under the surface; and (3) modified (M2) deployment, with bags submerged ~6 cm under the surface. Significant differences in bird diversity were found only between S and M2 bags; of the nine species observed on S bags during the experiment, only two (*P. auritus* and *L. marinus*) were seen on M2 bags. Three factors likely contributed to the decrease in diversity on M2 bags: depth (6 cm) at which the bag itself was maintained, floater instability, and interactions with floating organic debris. In terms of bag depth, it is noteworthy that both *P. auritus* and *L. marinus* have long tarsi, averaging approximately 8 and 9 cm, respectively (The New Brunswick Museum); species that avoided M2 have comparatively short tarsi. An influence of depth is consistent with reports of coastal birds changing their roost location with rising tides (e.g., Luis et al., 2001; Rogers, 2003; Rosa et al., 2006). The M2 modification also increased floater instability. Our field notes indicate that the roosting time was very short (seconds) when *P. auritus* and *L. marinus* successfully landed on the M2 floaters; it was also noted that other species attempted to roost on M2 floaters but failed and immediately flew away. Lastly, S and M2 bags interacted differently with floating debris. S bags were often covered with common eelgrass (*Zostera marina*), which can be uprooted following storm events; M2 bags were generally free of this marine plant. This observation appears relevant because *S. hirundo* was occasionally seen feeding on small invertebrates entangled within *Z. marina*.

With respect to abundance, the total counts on S bags were dominated by *P. auritus* and *Larus* spp. The experiment showed that M2 bags attracted significantly fewer *P. auritus*. The reason(s) for M2 selecting against *P. auritus* cannot be determined with certainty. As indicated above, it is known that *P. auritus* has a marked preference for elevated perches where it can spread its wings to dry its feathers (Hatch and Weseloh, 1999). Floater instability and the depth of M2 bags probably prevented this behaviour. Gulls, on the other hand, do not exhibit this behaviour, which may explain why none of the experimental bag types significantly reduced the abundance of *Larus* spp.

4.2.1. Floating cages experiment

In this experiment, the effectiveness of a bird-deterrent device, the AntiCormo developed by Bouctouche Bay Industries Ltd., was evaluated at two sites over an 18-week period. The AC can be fitted onto existing floating cages as shown in Fig. 3e. In the absence of the AC device, floating cages generally attracted several birds as was expected from earlier survey results. This outcome indicates that local breeding populations, essential for the testing of the AC device, were present at the two experimental sites.

The AC device considerably reduced the number of birds roosting on floating cages at both experimental sites, with mean abundance falling from several hundred birds per 100 cages to null (or near null) values. Field notes indicate that the highest abundances at the Bouctouche site (e.g., mean of 41.9 birds/100 cages, week 9) were mainly associated with improperly installed AC devices. There were no indications that the birds adapted to properly installed AC devices. Therefore it appears that the AC was a harassing physical barrier, comparable to metal spikes or prongs commonly mounted, for example, on top of navigation buoys, park lights and gutters.

It is noteworthy that floating cages are occasionally flipped to control biofoulers as part of normal husbandry procedures. Once flipped, AC structures are submerged and the entire wire-mesh cage is exposed to air, thereby desiccating biofoulers. In our study, birds quickly resumed their roosting activities at times when cages were flipped. In New Brunswick, growers flip cages three to five times per year, and the desiccation of biofoulers normally occurs over 48 h, after which cages are returned to their normal position and the AC devices resume their full functionality. Evidently, cage flipping should be avoided some time prior to oyster harvesting. The "no-flip" period could be as short as 14 days in cases where there is follow-up testing for coliforms (Canadian Shellfish Sanitation Program, 2005).

5. Conclusion

This report presented possible mitigation measures to prevent the roosting of birds in oyster farms along the eastern coastline of New Brunswick. For floating bags, results suggested that floater instability coupled with an immersion depth of approximately 6 cm (for the bag itself) were effective deterrents to birds. Depth and floater instability were achieved simply by attaching loose ropes between floaters and bags. However, we recognize that this deployment scheme may not represent a practical option for the industry, given that bags must occasionally be flipped and exposed to air in order to control (desiccate) fouling organisms. Hence it is unlikely that the bag prototypes tested in the present investigation will be adopted by the industry. To date, no practical design has been found for floating bags, although the reported information on bird behaviour in the present report is useful for ongoing research.

For floating cages, a dented triangular structure (AC) mounted on top of each floater was an effective deterrent to birds. Moreover, from a practical perspective, the AC does not interfere with normal husbandry procedures. New floaters, commercially produced by Bouctouche Bay Industries Ltd. (New Brunswick, Canada), incorporate the AC (USA Patent No. D578,424 and Canadian Registration No. 125146).

Acknowledgements

Ève-Julie Arsenault, Tina Rousselle, and Roland Chiasson patiently identified and counted the birds; Alyre Chiasson, Rhéal Savoie, Marie-Josée Maillet, Marcel Léger, Christian Norris, Abel Noel, Sylvio Doiron, and Bettie Arsenault assisted in developing the project; Joe Caissie, Paul Savoie, Martin Mallet, and Serge Leblanc kindly provided access to the study sites. This study was funded by

the Professional Shellfish Growers Association of New Brunswick in partnership with the Department of Fisheries and Oceans of Canada (Aquaculture Collaboration Research and Development Program, project MG-06-04-003) and the New Brunswick Department of Agriculture and Aquaculture.

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RE: Suspended Oyster aquaculture lease application by Bar Harbor Oyster Co., LLC for a 24.5 acre lease located in Mt. Desert Narrows between Israel Point and Thomas Island, Bar Harbor, Maine

July 23, 2016

Dear Aquaculture Hearing Officer and Ms. Dean & Ms. Burke,

I am writing to express my strong opposition to granting such a lease. My objection is based on well documented evidence that the type of floating gear (Oyster Gro) being proposed to be used at this site, and the methodology of flipping them to "desiccate sea growth", is known to attract sea birds.

Supporting this evidence, the DMR's own Site Review (#2015-10) conducted on 9/25/2015 shows on page 3, a picture (Image 1) of 3 cormorants, one on each of the 3 floating cages in a string, at the experimental site. The report summarizes this fact on page 16, and also reports on a small flock of gulls. Extrapolating this documented finding then, is it possible that when the lease site is fully operational with 1240 floating cages, there will be, among other birds, 1200+ cormorants below the flight path?

Two significant problems result from such attraction:

First, the oysters suspended within the cages are exposed to significant and concentrated amounts of bird fecal matter, leading to their potential contamination. In a You Tube video that we took on 9/27/2015 at the experimental site in Mt Desert Narrows https://youtu.be/FKY93V7F8TI, not only were there cormorants perching on the floating cages as per above, again in a near 1 for 1 ratio, there was clear evidence of numerous fecal matter deposits on the floats and cages below and water immediately surrounding them. Also attached to this letter, is a thorough, well documented Canadian study which has innumerable references to seabirds being attracted to such floating cages, particularly when they are flipped, and also confirming the fecal contamination problems that are known to result.

Second, and of even greater concern, is the fact that by attracting birds to the lease area, which is directly under a flight path to Bar Harbor Regional Airport, and within 10,000 of same, the proposed operation will create an unnecessary air traffic safety risk, to the flying public and those who work, travel and live in proximity to the airport.

While the DMR has taken the position that it has no responsibility for Air Safety, by allowing a known bird attractant to be placed within proximity to this airport as is proposed, the DMR will be complicit in exacerbating risks to the public at large, without having weighed the adequacy of preventive methods to avert such risks, including specific details of the equipment used and the exact operational practices employed, which the DMR does have explicit responsibility for. In addition, unless some alternative public process is established, through which the air safety aspects of this application are evaluated with equal thoroughness and openness as the DMR applies to overseeing its "mandated criteria", this matter of grave public concern to Maine residents and visitors, will possibly again be dealt with "behind closed doors" by the two Federal Agencies responsible for the Air Safety aspects of this lease.

In summary, I urge you to deny approval of the proposed lease. I also request that the DMR advocate for the establishment of a **publicly open process** by the US Army Corps of Engineers and FAA to deal with permitting the use of suspended aquaculture at this location.

Sincerely,

William S. Stockman
580 Oak Point Rd.
Trenton, Maine, 04605

RECEIVED
JUL 25, 2016
Maine Department of
Marine Resources

July 20, 2016

Maine Department of Marine Resources

Attention: Aquaculture Hearing Officer

While aquaculture is very important to the state of Maine I find it difficult to understand why any person would decide to place a site for aquaculture next to a busy airport. Maine is blessed with many, many miles of coastline and coves that would be suitable for aquaculture therefore the idea to even propose a site within 2 miles of a small but very busy airport seems unnecessary and a huge safety concern. The Bar Harbor Oyster site is directly under a runway approach and in the way of seaplanes. These oyster farms are notorious bird attractions and therefore make bird strikes much more likely. This situation makes a safety issue for people in the air and on the ground.

I believe in the interest of safety the oyster farm should be located at another place which would not endanger the public.

Sincerely, Kimberly Nadel 31 Osprey Lane, Trenton, Maine 04605