

**LEADING THE WAY: EXAMINING ADVANCES
IN ENVIRONMENTAL TECHNOLOGIES**

HEARING
BEFORE THE
SUBCOMMITTEE ON ENVIRONMENT
COMMITTEE ON SCIENCE, SPACE, AND
TECHNOLOGY
HOUSE OF REPRESENTATIVES
ONE HUNDRED FIFTEENTH CONGRESS

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June 21, 2017

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**LEADING THE WAY: EXAMINING ADVANCES
IN ENVIRONMENTAL TECHNOLOGIES**

WEDNESDAY, JUNE 21, 2017

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENVIRONMENT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Andy Biggs [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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Subcommittee on Environment

Leading the Way: Examining Advances in Environmental Technologies

Wednesday, June 21, 2017

10:00 a.m.

2318 Rayburn House Office Building

Witnesses

Mr. Sebastien De Halleux, Chief Operating Officer, Saildrone Inc.

Dr. Neil Jacobs, Chief Atmospheric Scientist, Panasonic Avionics

Dr. Burke Hales, Professor in Ocean Ecology and Biogeochemistry, College of Earth, Ocean and Atmospheric Sciences, Oregon State University

**U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY**

HEARING CHARTER

Wednesday, June 21, 2017

TO: Members, Subcommittee on Environment
FROM: Majority Staff, Committee on Science, Space, and Technology
SUBJECT: Subcommittee Hearing: “Leading the Way: Examining Advances in Environmental Technologies”

The Subcommittee on Environment will hold a hearing titled *Leading the Way: Examining Advances in Environmental Technologies* on Wednesday, June 21, 2017, at 10:00 a.m. in Room 2318 of the Rayburn House Office Building.

Hearing Purpose:

The purpose of this hearing is to highlight advances in environmental technologies. The hearing will focus on innovative monitoring, observing, and modelling technologies that support and enhance our understanding of the oceans and atmosphere.

Witness List

- **Mr. Sebastien De Halleux**, Chief Operating Officer, Saildrone Inc.
- **Dr. Neil Jacobs**, Chief Atmospheric Scientist, Panasonic Avionics
- **Dr. Burke Hales**, Professor in Ocean Ecology and Biogeochemistry, College of Earth, Ocean and Atmospheric Sciences, Oregon State University

Staff Contact

For questions related to the hearing, please contact Majority Staff at 202-225-6371.

Chairman BIGGS. The Subcommittee on Environment will come to order.

Without objection, the Chair is authorized to declare a recess of the Subcommittee at any time.

We welcome you to today's hearing, which is entitled "Leading the Way: Examining Advances in Environment Technologies."

All right. I recognize myself to give an opening statement.

Good morning, and welcome to today's Environment Subcommittee hearing entitled "Leading the Way: Examining Advances in Environmental Technologies." First of all, I thank each of our excellent panelists for being here today. I'm grateful that you're here.

For a hearing such as this one, there are many different avenues we could explore, but certainly one of undeniable importance is atmospheric monitoring. Without accurate atmospheric monitoring, we simply have no good way to predict the weather and, in turn, no ability to ensure that citizens are kept out of harm's way when severe weather arises.

In the federal government, the National Oceanic and Atmospheric Administration, NOAA, is tasked with issuing forecasts that inform millions of Americans each day. To make these forecasts, NOAA also spends billions of dollars on environmental observation and data collection. I have no doubt that NOAA plays a vital role in atmospheric monitoring and weather forecasting. But one of the questions we need to explore in this hearing is whether it makes sense for NOAA to provide all weather data, to be the exclusive provider of weather data.

In the 21st century, the landscape has changed. The federal government isn't the only game in town, nor, I would argue, should it be. Partners in the private sector can and should use their advanced and innovative technologies to better our weather predictions. Unfortunately, NOAA has been reluctant to seek the help it needs. In the face of degraded forecasting capabilities and aging satellite systems, NOAA has continued to solve all of its problems alone, thereby wasting time and government resources. Instead of continuing to think inside the government-only box, NOAA needs to look to private partners who are ready and willing to help.

Earlier this year, President Trump signed into law the Weather Research and Forecasting Innovation Act, a comprehensive bill to increase our weather forecasting capabilities to better protect lives and property. I commend Chairman Lamar Smith for his leadership on this bill, as well as the bill's original sponsor, Vice Chairman Frank Lucas. What I like most about this bill is that it compels NOAA to innovate. For far too long we have relied on outmoded government technologies and systems. Thankfully, the Weather Bill dictates that NOAA must partner with the growing private sector to test and validate its data in order to enhance our nation's forecasting capabilities. It is my hope that the agency will take full advantage of this opportunity.

Switching gears slightly, we will also hear today about innovative technologies deployed in the oceans and how they can significantly influence a number of areas of our lives as well. As ocean researchers engage in a wide variety of tasks, from collecting data that feeds into our weather models to taking ocean measurements

that are used to keep commercial shippers safe, these men and women are increasingly using cutting-edge science and technology. By partnering with our commercial sector, we can decrease government costs and ensure that data streams continue to flow. As President Trump considers new leadership at NOAA, I hope that he will select an Administrator who is willing to seriously consider the benefits of private innovation.

I look forward to learning more today about some of the technologies that will lead the way to a better and smarter future, and I yield back.

[The prepared statement of Chairman Biggs follows:]



COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
 Lamar Smith, Chairman

For Immediate Release
 June 21, 2017

Media Contact: Kristina Baum
 (202) 225-6371

Statement of Chairman Andy Biggs (R-Ariz.)

Leading the Way: Examining Advances in Environmental Technologies

Chairman Biggs: Good Morning and welcome to today's Environment Subcommittee hearing, entitled "Leading the Way: Examining Advances in Environmental Technologies." I'd like to first thank our excellent witnesses for being here today.

For a hearing such as this one, there are many different avenues we could explore, but certainly one of undeniable importance is atmospheric monitoring. Without accurate atmospheric monitoring, we simply have no good way to predict the weather and, in turn, no ability to ensure that citizens are kept out of harm's way when severe weather arises. In the federal government, the National Oceanic and Atmospheric Administration, NOAA, is tasked with issuing forecasts that inform millions of Americans each day. To make these forecasts, NOAA also spends billions of dollars on environmental observation and data collection.

I certainly have no doubt that NOAA plays a vital role in atmospheric monitoring and weather forecasting. But one of the questions we need to explore in this hearing is whether it makes sense for NOAA to provide all weather data. In the 21st century, the landscape has changed. The federal government isn't the only game in town, nor, I would argue, should it be.

Partners in the private sector can—and should—use their advanced and innovative technologies to better our weather predictions. Unfortunately, NOAA has been reluctant to seek the help it needs. In the face of degraded forecasting capabilities and aging satellite systems, NOAA has continued to solve all of its problems alone, thereby wasting time and government resources. Instead of continuing to think inside the "government-only" box, NOAA needs to look to private partners who are ready and willing to help.

Earlier this year, President Trump signed into law the Weather Research and Forecasting Innovation Act, a comprehensive bill to increase our weather forecasting capabilities to better protect lives and property. I want to commend Chairman Lamar Smith for his leadership on this bill, as well as the bill's original sponsor, Vice-Chairman Frank Lucas.

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By partnering with our commercial sector, we can decrease government costs and ensure that data streams continue to flow. As President Trump considers new leadership at NOAA, I hope that he will select an Administrator who is willing to seriously consider the benefits of private innovation.

I look forward to learning more today about some of the technologies that will lead the way to a better and smarter future.

I yield back.

###

Chairman BIGGS. And I now recognize the gentlewoman from Oregon, the Ranking Member, Mrs. Bonamici—Ms. Bonamici for an opening statement.

Ms. BONAMICI. Thank you very much, Mr. Chairman, and thank you to all the witnesses for being here today.

Federal investment in policies can incentivize and drive the development of new, innovative technologies. And these technologies can help us find creative solutions to our most troubling problems. We're fortunate to have with us today three witnesses who have all worked with NOAA to bring their technologies to the public. This hearing gives us the opportunity to discuss the importance of federal engagement with nonfederal partners.

One of the great things about new technology is that even small innovations can have a large and meaningful effect on our lives. Dr. Hales' Burkolator is an excellent example of this. The Burkolator is an autonomous analyzer the size of a piece of carry-on luggage that has helped shellfish growers across the Pacific Northwest determine the best time to grow larva. The Burkolator can determine the oceans' ability to form the calcium carbonates needed for shell formation, and it can be installed on ships. The Burkolator is available commercially, and it's allowed shellfish growers to take control of their livelihoods by putting the tools they need to be successful at their fingertips. None of this would have been possible without the federal research grants that provided the initial funding.

Although the range of technologies we're discussing in today's hearing is narrowly focused on oceanic and atmospheric observations, it's important to note that both the EPA and NOAA cover a broad range of environmental monitoring and observations that would be negatively affected by the President's proposed budget for fiscal year 2018. The President's proposed budget would cut EPA's state and local air quality management grants by 30 percent, which would have a devastating effect on the ability of many state and local agencies to adequately maintain their ambient air quality monitoring programs. This could lead to negative public health outcomes for many residents.

Similarly, the proposed cuts to numerous NOAA grant programs would severely limit the ability of the agency to meet its mission on environmental monitoring and observations. Although I'm looking forward to today's discussion about new technologies, we must remember that fundamental science at federal agencies such as the EPA and NOAA are on the chopping block under this Administration.

As we listen to our witnesses, let's acknowledge that federal agencies play an integral role in funding and accelerating the development of new technology to fit specific needs of niche markets or entire sectors. This is the Science Committee, and I want to emphasize how critical it is for Congress to continue to fund basic science at both NOAA and the EPA.

The President's budget proposes cuts to fundamental scientific research funding at EPA's Office of Research and Development by almost 50 percent, and NOAA's Office of Oceanic and Atmospheric Research is slated to be cut by 32 percent. These numbers are unacceptable, and they demonstrate that this Administration lacks an

understanding or concern about the importance of scientific research and promoting public health and protecting the environment and property.

I'd also like to draw attention to the troubling fact that there have been no nominations to fill any appointed positions at NOAA since the beginning of this Administration. This vacuum of leadership has left the agency, well, rudderless, pardon the pun, with line offices neglected. The mission of NOAA's line offices are simply too important and the stakes too high for us to wait any longer. Our Committee must be advocates for NOAA's role in our economy and for the safety of our citizens who rely on their research and data.

We need to have discussions about the state of science at NOAA and the EPA and its leadership, and I hope that we are able to have a frank and open conversation about the future of both agencies soon.

And I want to add, Mr. Chairman, you mentioned the Weather Forecasting Innovation Act. I was a proud cosponsor of that act and worked on it for actually several years, beginning with a former Environment Subcommittee Chair, Representative Stewart, and then the next Subcommittee Chair Mr. Bridenstine, as well as Mr. Lucas. So, we spent a lot of time talking about that bill, and I look forward to continuing conversations about its implementation.

So, again, I look forward to the discussion with our witnesses today about the exciting technologies that they are working on, as well as the integral role that federal investments play in promoting innovation within the realm of environmental monitoring in both the private sector and academia.

And with that, I yield back the balance of my time.
[The prepared statement of Ms. Bonamici follows:]

OPENING STATEMENT
Ranking Member Suzanne Bonamici (D-OR)
of the Subcommittee on Environment

Committee on Science, Space, and Technology
Subcommittee on Environment
"Leading the Way: Examining Advances in Environmental Technologies"
June 21st, 2017

Thank you, Mr. Chairman. And thank you to our witnesses for being here today.

Federal investment and policies can incentivize and drive the development of new, innovative technologies, and these technologies can help us find creative solutions to our most troubling problems. We are fortunate to have with us today three witnesses who have all worked with NOAA to bring their technologies to the public. This hearing gives us the opportunity to discuss the importance of federal engagement with non-federal partners.

One of the great things about new technology is that even small innovations can have a large and meaningful effect on our lives. Dr. Hales' "Burke-o-Lator" is an excellent example of this. The "Burke-o-Lator" is an autonomous analyzer the size of a piece of carry-on luggage that has helped shellfish growers across the Pacific Northwest determine the best time to grow larvae. The "Burke-o-Lator" can determine the ocean's ability to form the calcium carbonates needed for shell formation, and it can be installed on ships. The "Burke-o-Lator" is available commercially, and it's allowed shellfish growers to take control of their livelihoods by putting the tools they need to be successful at their fingertips. None of this would have been possible without the federal research grants that provided the initial funding."

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Although I am looking forward to today's discussion about new technologies, we must remember that fundamental science at federal agencies, such as the EPA and NOAA, are on the chopping block under this Administration. As we listen to our witnesses, let's acknowledge that federal agencies play an integral role in funding and accelerating the development of new technology to fit specific needs of niche markets or entire sectors.

This is the Science Committee, and I want to emphasize how critical it is for Congress to continue to fund basic science at both NOAA and the EPA. The President's Budget proposes

cuts to fundamental scientific research funding at EPA's Office of Research and Development by almost 50 percent, and NOAA's Office of Oceanic and Atmospheric Research is slated to be cut by 32 percent. These numbers are unacceptable and demonstrate that this Administration lacks understanding or concern about the importance of scientific research in promoting public health and protecting the environment and property.

I would also like to draw attention to the troubling fact that there have been no nominations to fill any appointed positions at NOAA since the beginning of this Administration. This vacuum of leadership has left the agency, well, rudderless, with line offices neglected. The mission of NOAA's line offices are simply too important, and the stakes too high, for us to wait any longer. Our committee must be the advocates for NOAA's role in our economy, and for the safety of our citizens who rely on their research and data. We need to have discussions about the state of the science at NOAA and EPA and its leadership, and I hope that we are able to have a frank and open conversation about the future of both agencies soon.

I look forward to the discussion with our witnesses today about the exciting technologies that they are working on, as well as the integral role that federal investments play in promoting innovation within the realm of environmental monitoring in both the private sector and academia. With that I yield back the balance of my time.

Chairman BIGGS. Thank you, Ms. Bonamici.

I am going to introduce—begin introducing our witnesses. Our first witness today is Mr. Sebastien de Halleux, Chief Operating Officer at Saildrone, Inc. Mr. de Halleux is the recipient of the 2012 EA Emerging Leaders Award, the 2011 Tech 100 Award, the 2010 Tech Fellow Award, and the 2003 Booz Allen Professional Excellence Award. He received his master's degree in civil and environmental engineering from Imperial College London.

And our second witness is Dr. Neil Jacobs, Chief Atmospheric Scientist at Panasonic Avionics. Previously, Dr. Jacobs worked on various projects, including NASA's Earth Systems Science Program, GOES Satellite Imagery, Department of Energy's Ocean Margins Program at the National Weather Service's Atlantic Surface Cyclone Intensification Index. He received bachelor's degrees in mathematics and physics from the University of South Carolina, and an M.S. in air-sea interaction and a Ph.D. in numerical modeling from North Carolina State University.

I now yield to Ms. Bonamici to introduce our third witness, Dr. Burke Hales.

Ms. BONAMICI. Thank you, Mr. Chairman.

I am pleased to welcome to the Committee and introduce Dr. Burke Hales, a Professor of Ocean Ecology and Biogeochemistry in the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University.

Dr. Burke has an undergraduate degree—excuse me, Dr. Hales has an undergraduate degree in chemical engineering and a doctorate in chemical oceanography from the University of Washington.

Dr. Hales has had many noteworthy accomplishments over the course of his career where much of his research has been focused on coastal ocean carbon cycles, ocean acidification monitoring, and experimental technology.

Recently, Dr. Hales' most publicized work has been developing a technology called the Burkolator that is used by shellfish farmers in Oregon to help them deal with the rising acidity of the ocean. And I look forward to hearing more about that in his testimony.

Thank you to Dr. Hales and the other witnesses for being here today, and I yield back.

Chairman BIGGS. Thank you. I now recognize Mr. de Halleux for five minutes to present his testimony.

Can you please press the mic button? There we go.

**TESTIMONY OF MR. SEBASTIEN DE HALLEUX,
CHIEF OPERATING OFFICER,
SAILDRONE INC.**

Mr. DE HALLEUX. Thank you, Mr. Chairman and Members of the Environment Committee, for providing an opportunity to discuss this important topic of environment technology advances. It's an honor to testify in front of your Subcommittee.

My name is Sebastien de Halleux, and I'm the Chief Operating Officer of Saildrone, a company based in Alameda, California. We have developed unmanned surface vehicle technologies focused on collecting ocean data cost-efficiently, at scale, providing insights

into systems like weather forecasting, fish stocks, marine life, surface and subsurface maritime traffic.

Oceans play a key role in our nation's continued economic growth, contributing an estimated \$359 billion in gross domestic product. Of all observation, in situ ocean data is critical to understand global systems, yet collecting in situ ocean data is expensive because it relies on ships. A government research vessel costs anywhere between \$100–200 million to purchase and \$35,000 to \$60,000 a day to operate.

If I could have slide 1?

[Slide.]

The commercial sector has developed cost-efficient—the previous slide, please.

The commercial sector has developed cost-efficient environment technology advances in response to this problem, an example of which is the Saildrone unmanned surface vehicle, which you can see on the slide, capable of missions of up to 12 months using no fuel, but wind power alone for propulsion. Each 23-foot-long USV carries a suite of sensors monitoring key environmental variables covering the atmospheric, surface, and subsurface domains and using a persistent satellite communication link to send this data in real time back to shore.

USVs of this type are good for many different government applications and serve as both defense and civilian needs, including maritime domain awareness, drug interdiction, weather forecasting, fish stock assessment, and other environmental observations.

Of course, data quality and cost-efficiencies are key and both have been demonstrated over 100,000 nautical miles of missions in partnership with NOAA, which has deemed the Saildrones, quote, “a platform that is ready for ocean research, missions from the tropics to the Arctic,” end quote.

And like many technology advances in the past, Saildrone USVs are offered as a fully managed service, including the USV lease, its operation, the data management, distribution for fixed daily price per USV without requiring expensive up-front investments. And in getting the private sector to pay for the expensive infrastructure and shouldering the operational risk, this public-private partnership framework provides great value to NOAA.

Slide 2, please?

[Slide.]

NOAA's current fleet of 16 research and survey ships is currently unable to meet the internal demand for days at sea, over 3,000 unaddressed days at sea in fiscal year 2017 according to NOAA's own fleet plan. This shortage and NOAA's recognized ocean data gaps can be addressed by USV technology, augmenting NOAA's ships, though only for those roles requiring data collection, i.e., the long tail of data collection, as higher capabilities will always require actual ships.

However, despite being a very effective R&D partner, NOAA has no clear pathway or budget to move this type of technology innovation from R&D into operation, and therefore, not realizing the associated cost savings. We would recommend that such a pathway to operation be better defined.

The Weather Research and Forecasting Innovation Act that you mentioned stops short of defining a clear public-private partnership framework and remains ambiguous in defining the type of data that it encourages NOAA to source in the private sector. We would recommend that these ambiguous data types be clarified to include ocean surface observation, thus encouraging such public-private partnerships.

Yet in spite of the challenges mentioned here, the Nation still holds a leadership position and a strategic advantage in environmental observation and the technologies that make those observations possible, reliable, and accurate. U.S. policy and regulatory mechanism need to reflect the current status of technology and market factors and also anticipate more innovative technological developments with an eye towards efficient addressing of mission and incentive-creation for U.S. industry. The Nation as a whole benefits from such an approach.

I would like to thank you for the opportunity to express my views today, and I'm prepared to answer any question you might have. [The prepared statement of Mr. de Halleux follows:]

Statement of
Mr. Sebastien de Halleux,
Chief Operating Officer, Saildrone, Inc.

Before the

Subcommittee on Environment
Science, Space, and Technology Committee
U.S. House of Representatives

Hearing on
“Leading the Way:
Examining Advances in Environmental Technologies”

June 21, 2017

Key points

- Oceans play a key role in our nation’s continued economic growth, contributing an estimated \$359 billion in gross domestic product.
- In-situ ocean data is critical to understanding global systems yet collecting in-situ ocean data is expensive as it relies on ships
- The commercial sector is providing cost-efficient environmental technology advances in response to this problem, an example of which is the Saildrone Unmanned Surface Vehicles (USVs), capable of missions of up to 12 months using wind power for propulsion
- USVs of this type allow for many different government applications, and service both Defense and Civilian needs
- Data quality and cost-efficiencies are key and both have been demonstrated in partnership with NOAA which has deemed the saildrones “*a platform that is ready for ocean research missions from the tropics to the Arctic*”
- NOAA’s current days-at-sea shortage and ocean data gaps could be addressed by USV technology augmenting NOAA’s ships.
- However, despite being an effective R&D partner, NOAA has no clear pathway or budget to move this type of technological advances from research into operations and is thus not realizing the associated cost-savings.
- We would recommend that such a pathway to operations be better defined.
- The Weather Research and Forecasting Innovation Act of 2017 stops short of defining a clear public-private partnership framework and remains ambiguous in defining the type of data it encourages NOAA to source from the private sector.
- We would recommend that these ambiguous data types be clarified to include ocean surface observations thus encouraging such public-private partnerships.

Thank you, Mr. Chairman and Members of the Environment Subcommittee, for providing an opportunity to discuss the important topic of sustaining U.S. leadership through the leveraging of advances in environmental technologies. This topic cuts across vital American commercial, economic, and national security interests in many different ways. In particular, my testimony will focus on two key areas. First, how the latest advances in environmental technologies can increase mission effectiveness of both Civilian agencies – for example, the National Oceanic and Atmospheric Administration – as well as to the U.S. Department of Defense. Second, I will make some suggestions about facilitating the transition from research to operational deployment, in order to generate positive economic impact and provide the best value to taxpayers.

My name is Sebastien de Halleux, and it is my honor to testify here today. I am the Chief Operating Officer of *Saildrone Incorporated*, a company based in Alameda, California. We have developed unmanned surface vehicle technologies, which collect ocean data with unprecedented cost-efficiencies at global scale, providing enhanced insights into systems like weather, fish stocks and marine life, surface and sub-surface maritime traffic. Our unmanned surface vehicle technologies generally make such systems more visible, predictable and actionable for the nation, with the goal to create direct positive economic impact and help protect lives and property. Our company currently employs 30 people and has operations across the US maritime sectors, from the Bering Sea to the Tropical Pacific, the Gulf of Mexico and the Atlantic.

Current Context

Oceans cover over 71 percent of the planet and represent a key domain that impacts the nation. For example, oceans are key drivers of weather patterns -- including most notably, catastrophic events such as floods, droughts and hurricanes. Additionally, oceans provide a major source of food (the estimated U.S. per capita consumption of fish and shellfish was 15.5 pounds in 2015¹). Oceans facilitate maritime transport, essential to the world's economy since over 90% of the world's trade is carried by sea². Finally, they play an important role in the energy sector, where an estimated 30% of global oil and gas now comes from offshore.

Most importantly, the ocean economy in the US was estimated to directly contribute to 149,000 business establishments, 3.0 million employees, \$117 billion in wages³, and \$359 billion in gross domestic product. Consequently, a better understanding of the ocean domain through the use of advances in environmental technologies is critical in achieving our nation's continued economic growth.

Additionally, in order to better understand our global ocean systems, several existing environmental technologies which collect ocean data, are used. Satellites successfully provide the big picture. However, spatial and temporal resolution of satellites are limited and remote sensing techniques are only capable of measuring the top surface or 'skin' of the oceans. To study the deep oceans, profilers and buoyancy gliders are used to sample salinity and temperature profiles. A key data gap remains in the surface maritime domain and specifically, the air-sea interface.

¹ NOAA National Marine Fisheries Service, "Fisheries of the United States" report, 2015

² United Nations International Maritime Organization (IMO)

³ The NOAA Fleet Plan: Building NOAA's 21st century fleet

The reason for this data gap is that collecting *in-situ* ocean data is expensive, because it relies on ships and buoys. A government research vessel costs anywhere between \$100-200m to purchase and \$35,000 to \$60,000 a day to operate. NOAA operates a fleet of 16 research and survey ships. Yet, the U.S. Exclusive Economic Zone or EEZ is the largest in the world, containing 3.4 million square nautical miles of ocean, larger than the combined land area of all fifty states⁴. In addition of being a vast domain, the oceans are also a dangerous environment, regularly putting lives at risk.

The Commercial Sector Offers Innovative, Effective and Efficient Environmental Monitoring Technologies

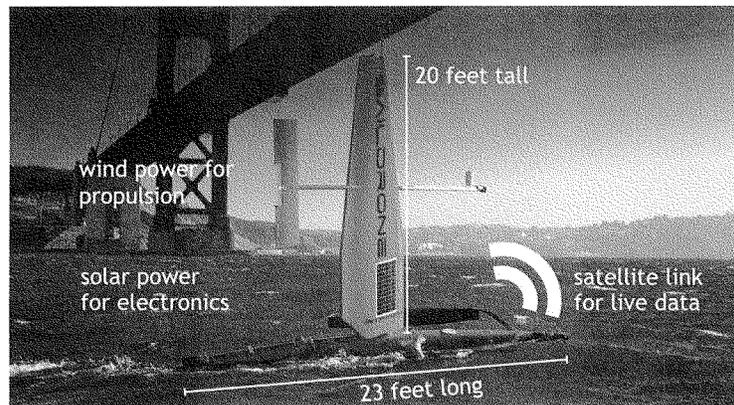


Figure 1 - a Saildrone USV on its way to a data collection mission in the Pacific

⁴ source: NOAA

In response to these challenges in observation for the maritime domain, the commercial sector has developed responsive, cost-efficient and innovative environmental technologies. In particular, the solution SAILDRONE has developed to address them is an unmanned surface vehicle (or USV), which harvests all its energy from the environment it travels through. It uses wind-power for propulsion, provided by a patented wing technology, which evolved over 10 years of private sector R&D. Electricity for the onboard suite of sensors, computers and communication link is provided by photovoltaic panels.

Each USV is 23ft long, 20ft high, with a draft of 7ft and is using a persistent satellite communication link to transmit real-time data to shore. Each USV is capable of mission duration of up to 12 months in any ocean and has been extensively tested in extreme conditions in either grid survey or station-keeping mode. Additionally, each USV carries a suite of sensors monitoring key environmental variables, covering the atmospheric, surface and sub-surface domains, including wind strength and direction, humidity, temperature, solar radiation, magnetic field, sea surface temperature, wave height and period, water temperature, salinity, biogeochemistry and ocean currents. In addition, vehicles are equipped with passive acoustic sensor enabling the tracking of marine mammals and marine traffic, and with a sonar, enabling them to detect fish in the water column or take precise depth soundings.

Government applications

Our proprietary technology has been successfully deployed in the field and Sairdrones have accumulated over 100,000 nautical miles of missions, demonstrating its actual capabilities in a range of extreme environments. Sairdrone's capabilities allow for many different applications and service both

Defense and Civilian needs. Defense applications include the deployment of USVs for Maritime Domain Awareness. As our land borders are tightened, the flow of illegal drugs increasingly relies on offshore maritime routes, representing a detection challenge for DoD. Currently, SAILDRONE supports the DoD on drug interdiction missions, by providing persistent maritime domain awareness at sea.

Our Civilian applications – which include NOAA and NASA missions -- cover a wide range of ocean data collection from meteorological and oceanographic data collection to autonomous fish stock assessment to ground truthing satellite observations.

Data quality and Cost Efficiency are key

In any observation system, data quality is key. It is not enough to take an observation; it needs to be validated against known measurements. Such an evaluation of SAILDRONE's data has been performed by NOAA over the last 2 years, under a Collaborative Research and Development Agreement (CRADA), comparing data collected by SAILDRONE USVs with the same data collected by NOAA ships and buoys in the same location and at the same time. USV data has compared favorably with existing NOAA assets with scientists stating that: *“Outstanding correlation [was] found between SAILDRONE and ship calibrated measurements,”* and NOAA further stated that SAILDRONE USVs represent *‘a platform that is ready for ocean research missions from the tropics to the Arctic’*⁵

In the past, new technologies were expensive to acquire and even more expensive

⁵ “The Use of SAILDRONES to Examine Spring Conditions in the Bering Sea: Instrument Comparisons, Sea Ice Meltwater and Yukon River Plume Studies” Coker et al, IEEE, 2015

to maintain, resulting in large capital outlay, before proving any value. In contrast, Saildrone' ocean data capability is offered as a fully managed service including USV lease, operation, data management and distribution for a fixed daily price per USV (achieving cost efficiencies of the order of 90% cheaper than the daily cost of a government research vessel). In getting the private sector to pay for the expensive infrastructure and shouldering the operational risk, this public-private partnership framework provides great value to NOAA.

NOAA's days-at-sea shortage could be addressed by USV technology

NOAA states in its 'Fleet Plan' that the total internal demand for days at sea in fiscal year 2017 totaled 8,063 days-at-sea across its various missions. However, the current aging NOAA fleet can only provide 3,096 days-at sea. The shortfall is partially addressed by chartering private vessels for approximately 2,320 days-at-sea. This leaves an unaddressed gap of 3,191 days-at-sea in fiscal year 2017 alone.

Worse, NOAA further states that *"Between 2017 and 2018, eight of NOAA's [16] ships will exceed their design service life and are due to retire by 2028. The loss of these eight ships will undermine NOAA's ability to meet its mission. "*

This clearly will have consequences, which NOAA lists as: *" the total absence of mapping capabilities on the West Coast and in the United States Arctic, specifically in the Pacific Ocean, Bering Sea and Arctic Ocean; a 75 percent loss of its hydrographic survey capability on the East Coast and in the Caribbean; and the inability to conduct fishery and marine mammal stock assessments, monument and sanctuary stewardship in the Central, Southern, and Western Pacific, and trawl-based stock assessments in the Gulf of Mexico. [...] Moreover, the loss of*

data used to validate and calibrate satellites and feed weather forecasting models will result in less accurate planning for emergency response, agriculture, and coastal management that will increase risk to lives and property and have negative economic impacts.”

We believe that USV technologies can cost-efficiently address this gap and augment NOAA ships, while also potentially reducing the dependencies on expensive charters.

The long tail of ocean data collection

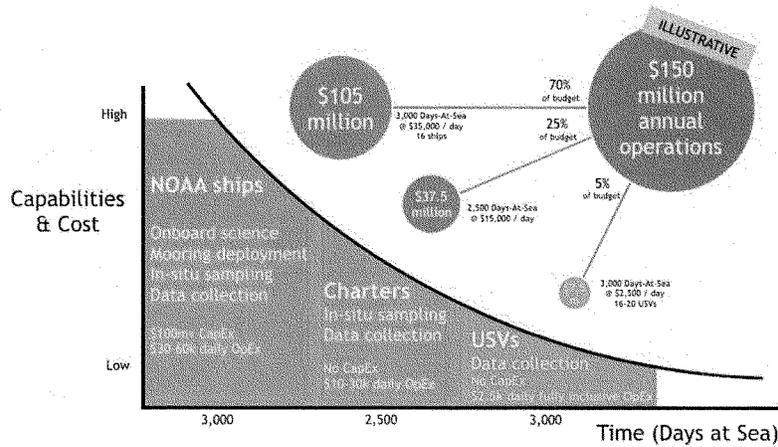


Figure 2 - The long tail of data collection

Naturally, different monitoring missions require different capabilities. Some circumstances require complex capabilities such as the ability to deploy heavy equipment, perform in-situ sampling of fish or water and perform complex onboard analyses. These uses cases clearly require a ship, which remains the bed-

rock of ocean research and a core component of NOAA's capabilities. We thus agree with NOAA's statement that *"It is a fallacy to assume that technology can replace ships"*.

However, for many missions where the capabilities only require data collection for long periods of time over large areas, USVs are uniquely qualified and could play an important role in increasing the mission effectiveness of NOAA.

The cost-efficiencies are clear: the operating cost of a government ship is approximately \$35,000 to \$60,000 a day, after an initial capital expense in excess of \$100m. A charter costs on average \$15,000 per day. In contrast, a Saildrone USV costs \$2,500 per day or a 90% cost saving for those missions which only require data collection. USVs, when offered on a data-as-service basis require no upfront capital expense, and shift the burden of operation and risk to the private sector.

Yet, NOAA today has no budget dedicated to operationalizing Unmanned Surface Vehicles nor a clear pathway to move this type of environmental technological advances from research into operations.

Fisheries for example would reap short term benefits from better fish stock assessment. And NOAA's weather models would also benefit from reducing their observational data gaps, by acquiring data collected from USVs such as those offered by our company and others.

Recommendation for better transfer of technology from research to operation

The US government has been an effective R&D partner to Saildrone. For example, we believe that the Collaborative Research & Development Agreement framework

(or CRADA) has enabled NOAA OAR to very efficiently work with companies like ours to assess and adapt private sector innovation to the unique needs of the agency.

However, the lack of pathways to transition technology from R&D to Operations is a known issue. This means that despite the fact that the US government recognizes the potential of emerging technologies like USVs, transitioning them to operations and realizing the associated cost-savings, has been challenging.

The **Weather Research and Forecasting Innovation Act of 2017** is meant to help, but stops short of providing a robust private-public partnership framework.

“Sec. 106) NOAA must: (1) prioritize observation data requirements necessary to ensure weather forecasting capabilities to protect life and property to the maximum extent practicable; (2) evaluate observing systems, data, and information needed to meet those requirements; (3) identify data gaps in observing capabilities; and (4) determine a range of options to address those gaps.”⁶

Furthermore, the bill’s authorization for the purchase of commercial weather data is ambiguous when it comes to the type of data considered, and especially its applicability to ocean surface data such as those provided by companies like ours.

TITLE III--WEATHER SATELLITE AND DATA INNOVATION

(Sec. 302) The bill permits the purchase of weather data by the federal government

⁶ H.R.353 - Weather Research and Forecasting Innovation Act of 2017 - 115th Congress (2017-2018)

through contracts with commercial providers and the placement of weather satellite instruments on co-hosted government or private payloads.

We would recommend that the Data Innovation mandate be clarified to include surface observations in order to help address NOAA's recognized data gaps in this area.

We would further recommend that NOAA be encouraged to transition technology assessed by OAR to operational line offices by directing funds for that specific purpose.

Closing Remarks

In spite of the challenges mentioned here, the nation still holds a leadership position and a strategic advantage in environmental observations and the technologies that make those observations not only possible, but also reliable and accurate. Activity is taking place at an accelerated pace, given technology and market developments, including the leveraging of advances in environmental technologies in an expanding maritime ecosystem. U.S. policy and regulatory mechanisms need to reflect the current status of technology and market factors, and even anticipate more innovative technological developments with an eye toward efficient and objective addressing of mission and incentive creation for U.S. industry. The nation as a whole benefits from such an approach.

In closing, I would like to thank you for giving me the opportunity to present some of the advancements in environmental technologies and to explain how companies like SAILDRONE can cost-effectively augment existing US government capabilities to better manage our country's resources and prepare our population

confronted with complex environmental challenges such as weather, fisheries and environmental monitoring.

Our company provides infrastructure to Government agencies to enable them to fulfill their mandate with a higher degree of success and higher cost efficiencies.

Such advances in USV technologies and data management provide new opportunities for public-private partnerships, as our work with NOAA and DoD have demonstrated.

I appreciate the opportunity to express my views to you today, and I invite any of the Members or staff to come visit SAILDRONE the next time you are on the West Coast.

Thank you for your attention. I am prepared to answer any questions that you may have.

For more information

- An IEEE publication by NOAA PMEL about the mission performance of the Sairdrone USV performing autonomous meteorological and oceanographical data collection in the Bering Sea:
<https://www.pmel.noaa.gov/pubs/PDF/mein4372/mein4372.pdf>
- An IEEE publication by NOAA PMEL about the instrument comparison between Sairdrone USVs and NOAA ships and buoys:
<https://www.pmel.noaa.gov/foci/publications/2015/coke0847.pdf>
- A Remote Sensing Journal publication about the performance of Sairdrone USV in autonomous oil spill detection in the Gulf of Mexico:
http://coaps.fsu.edu/~ddmitry/MyPapers/Asl_oilseeps_2017.pdf

Biography**Sebastien de Halleux**

Chief Operating Officer

Saildrone Inc.

Sebastien de Halleux is the Chief Operating Officer of Saildrone Inc., a company designing wind and solar powered ocean drones aiming at revolutionizing data collection at sea. At the confluence of autonomous technologies and big data, Saildrone believes that improving the understanding of our oceans will help us better understand key planetary systems that affect humanity such as weather and fisheries. Formerly, Sebastien was Co-Founder and COO of Playfish, one of the largest and fastest growing social gaming companies. Sebastien helped grow the company to over 300 million players in two years before being acquired by video game giant Electronic Arts (EA) in 2009. Prior to founding Playfish, Sebastien helped launch Glu Mobile, an early pioneer in mobile games which IPO'ed in 2007.

Sebastien is the recipient of the 2012 EA Emerging Leaders Award, the 2011 Tech 100 award, the 2010 TechFellow award, and the 2003 Booz Allen Professional Excellence Award. He sits on the boards of UWC-USA, the Solar Fuel Institute, and Trusted Family.

He is passionate about helping the next generation of entrepreneurs, acting as mentor for the Founders Institute, BetaGroup and 500 Startups. Sebastien holds a Masters degree in Civil and Environmental Engineering from Imperial College London and is a member of the 2016 Class of Henry Crown Fellows and the Aspen Global Leadership Network at the Aspen Institute.

Chairman BIGGS. Thank you. I now recognize Dr. Jacobs for five minutes to present his opening statement.

**TESTIMONY OF DR. NEIL JACOBS,
CHIEF ATMOSPHERIC SCIENTIST,
PANASONIC AVIONICS**

Dr. JACOBS. Good morning, Chairman Biggs, Ranking Member Bonamici, and Members of the Subcommittee. My name is Neil Jacobs, and I serve as Chief Atmospheric Scientist for Panasonic Weather Solutions, a division of Panasonic Avionics Corporation. I am honored to be invited to participate in today's hearing.

Panasonic is very pleased to continue our longstanding public-private partnership to provide TAMDAR data to the National Weather Service through the National Mesonet Program, which is an example of a successful business model for commercial atmospheric data acquisition. TAMDAR, which stands for tropospheric airborne meteorological data reporting, provides real-time observations of wind, temperature, moisture, pressure, icing, and turbulence. These data are downlinked through either Iridium's low-Earth orbiting satellite network or Panasonic's high-throughput geostationary satellite Ku band network. Once received, they are decoded, quality-controlled, and passed on to the National Weather Service with a latency of less than 20 seconds.

The aircraft-based weather observations are assimilated into the National Weather Service forecast models, and numerous studies have been conducted to document the substantial positive impact on predictive skill. Visualization of the raw observations can also be used to manually adjust regional forecasts for convective activity and precipitation type issued by the National Weather Service forecast offices.

The icing and turbulence observations can be used to enhance aviation situational awareness for both commercial and general aviation. These observations are used by the NTSB as a routine part of many aviation accident investigations.

The TAMDAR network is rapidly expanding overseas, and many airlines are utilizing both real-time observing systems and forecast models to enhance safety, as well as operational efficiency. Additionally, significant fuel savings are realized by the airlines, which has the added benefit of greatly reducing the footprint of—the carbon footprint of commercial aviation.

A miniaturized version of this sensor has been developed for UAVs. It is currently in operation on a number of platforms, including NASA's Ikhana, which is a nonweaponized predator drone used for scientific research. The probe has also the capacity to do additional sensing such as various air quality metrics.

In addition to the airborne sensing network, Panasonic is in the initial stages of deploying ship-based marine and atmospheric sensing capabilities through ITC Global, which is a Panasonic-owned company that supplies broadband to the maritime industry.

Panasonic is the only private entity in the world with a custom-developed global weather modeling platform initialized from raw observations and completely independent from NCEP-produced global model data. This prediction system includes an 80-member ensemble in addition to high-resolution deterministic model. The

global model is designed to assimilate both conventional observations, as well as satellite radiances among other remotely sensed data sources, including commercial GNSS radio occultation measurements. Panasonic also runs regional models in air quality dispersion models, which are initialized from boundary conditions provided by our global model.

The next-generation Panasonic global model will employ the capability to run various dynamic cores, some of which are currently being co-developed between public, private, and academic sectors. Further advancements are being made for the data assimilation system, as well as two-way coupling of an ocean model. As part of this development initiative, Panasonic has established a very successful academic-private partnership with multiple universities and institutions, including University of Maryland, North Carolina State University, and the National Center for Atmospheric Research. Panasonic funds several programs at these institutions, which support faculty and students in STEM-related fields.

While commercial restrictions are placed on the redistribution of Panasonic data and intellectual property, we routinely grant research-only license agreements to universities so that faculty and students have free access to our data for educational purposes. At Panasonic, we believe it is critical to the structure of public-private partnerships such that industry is incentivized to collaborate with federal agencies, as this is more convective to the mutual success of both sectors.

A thriving private sector in the weather enterprise can not only provide data, products, and services to enhance submission of various federal agencies but can also fast-track applied research and innovation through partnerships with the academic sector.

Since its founding in 1998, Panasonic Weather Solutions has worked cooperatively with federal agencies providing its data to NOAA and the FAA and at many times at no cost. While we are a commercial company responsible to our shareholders, we at Panasonic also have another responsibility to help share our technological expertise with the national meteorological agencies around the world.

Mr. Chairman, Ranking Member Bonamici, and Members of the Subcommittee, thank you again for inviting me to participate today. I would be pleased to answer any questions you may have.

[The prepared statement of Dr. Jacobs follows:]

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Statement of

Neil A. Jacobs. Ph.D.
Chief Atmospheric Scientist - Panasonic Weather Solutions
Panasonic Avionics Corporation

Before the

Subcommittee on Environment
Science, Space, and Technology Committee
U.S. House of Representatives

Hearing on

“Leading the Way: Examining Advances in Environmental
Technologies”

June 21, 2017

Good morning, Chairman Biggs, Ranking Member Bonamici, and Members of the Subcommittee. My name is Neil Jacobs, and I serve as the Chief Atmospheric Scientist for Panasonic Weather Solutions, a division of Panasonic Avionics Corporation. I am honored to be invited to participate in today's hearing to examine the advancement and progress that has been made on environmental technologies.

Panasonic is very pleased to continue our long-standing public-private partnership to provide TAMDAR data to the National Oceanic and Atmospheric Administration's National Weather Service through the National Mesonet Program, which is an example of a successful and sustainable business model for commercial atmospheric data acquisition.

TAMDAR, which stands for Tropospheric Airborne Meteorological Data Reporting, provides real-time observations of wind, temperature, moisture, pressure, icing, and turbulence. These atmospheric data are downlinked through either Iridium's low-Earth orbiting satellite network or Panasonic's high throughput geostationary satellite Ku-band network. Once received, the data are decoded, quality controlled, and passed on to the National Weather Service with a total latency of less than 20 seconds.

The aircraft-based weather observations are assimilated into the National Weather Service's forecast models, and numerous studies have been conducted to document the substantial positive impact on predictive skill. Visualization of the raw observations can also be used to manually adjust regional forecasts for convective activity and precipitation type issued by National Weather Service forecast offices.

The icing and turbulence observations, while not assimilated into the models, can be used to enhance aviation situational awareness for both commercial and general aviation pilots. These observations are also used by the National Transportation Safety Board as a routine part of many aviation accident investigations.

The TAMDAR network is rapidly expanding overseas, and many airlines are utilizing both the real-time observing systems and forecast model output to enhance both safety, as well as operational efficiency. In addition to passenger and crew safety, significant fuel savings are realized by the airlines, which has the added benefit of greatly reducing the carbon footprint of commercial aviation.

A miniaturized version of the TAMDAR sensor has also been developed for unmanned aerial vehicles. It is currently in operation on a number of platforms, including NASA's Ikhana, which is a non-weaponized Predator drone used for scientific research. The UAV probe functions identical to the commercial aviation version. It also has the capacity to do additional sensing, such as various air quality metrics.

In addition to the airborne sensing network, Panasonic is in the initial stages of deploying ship-based marine and atmospheric sensing capabilities through ITC Global, which a Panasonic Avionics-owned company that supplies broadband satcom to the maritime industry.

Panasonic is the only private entity in the world with a custom-developed, end-to-end global weather-modeling platform initialized from raw observations, and completely independent from National Weather Service-produced global model data. This prediction system includes an 80-member model ensemble in addition to a high-resolution deterministic model. The global model is designed to assimilate both conventional observations, as well as satellite radiances and other remotely-sensed data sources including commercial GNSS-radio occultation measurements. Panasonic also runs limited area regional models and air quality

dispersion models, which are initialized internally from the boundary conditions provided by the Panasonic global model.

The next-generation Panasonic global model will employ the capability to run various dynamic cores, some of which are being co-developed between public, private, and academic sectors. Further advancements are also being made to the data assimilation system, as well as two-way coupling of an ocean model.

As part of the global model development initiative, Panasonic has established a very successful academia-private partnership business model with multiple universities and academic institutions including University of Maryland, North Carolina State University, and the National Center for Atmospheric Research. Panasonic funds several programs at these institutions, which support faculty and students in the atmospheric modeling, environmental science, and related STEM fields.

While commercial restrictions are placed on the redistribution of Panasonic data and intellectual property, we routinely grant research-only license agreements to universities, so that faculty and students have free access to our data for educational purposes.

At Panasonic, we believe it is critical to structure public-private partnership models such that industry is incentivized to collaborate with federal agencies, as this is more conducive to the mutual success of both sectors. A thriving private sector in the weather enterprise can not only provide data products and services to enhance the mission of various federal agencies, but it can also fast-track applied research and innovation through partnerships with the academic sector.

Since its founding in 1998, Panasonic Weather Solutions has worked cooperatively with federal agencies by providing its TAMDAR data to NOAA and the FAA, and -- many times at no cost. While we are a commercial company responsible to our shareholders -- we at Panasonic also have another responsibility -- to help share our technological expertise with national meteorological agencies around the world.

Mr. Chairman, Ranking Member Bonamici, and Members of the Subcommittee, thank you again for inviting me to participate today. I would be pleased to answer any questions you may have about Panasonic Avionics Corporation.

Bio for Dr. Neil Jacobs – Panasonic Avionics Corporation

Dr. Jacobs directs the research and development of both the tropospheric airborne meteorological data reporting system (TAMDAR), as well as the numerical models run by Panasonic. His areas of expertise include mesoscale dynamics, numerical weather prediction, and data assimilation. He is the chair of the American Meteorological Society's Forecast Improvement Group (FIG), and also serves on the World Meteorological Organization's (WMO) aircraft-based observing systems expert team. Prior to joining Panasonic (AirDat) in 2005, Dr. Jacobs worked on various analyses and modeling projects including NASA's Earth Systems Science Program, GOES satellite imagery, Department of Energy's Ocean Margins Program, and the National Weather Service's Atlantic Surface Cyclone Intensification Index. He has a BS in mathematics and a BS in physics from the University of South Carolina, a MS in air-sea interaction from North Carolina State University, and a PhD in numerical modeling from North Carolina State University.

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Chairman BIGGS. Thank you, Dr. Jacobs.
I now recognize Dr. Hales for five minutes.

**TESTIMONY OF DR. BURKE HALES,
PROFESSOR IN OCEAN ECOLOGY AND BIOGEOCHEMISTRY,
COLLEGE OF EARTH,
OCEAN AND ATMOSPHERIC SCIENCES,
OREGON STATE UNIVERSITY**

Dr. HALES. Thank you, Chairman Biggs, Vice Chair Banks, and Ranking Member Bonamici, for the opportunity to speak to you today to discuss the importance of federal investment in environmental monitoring systems technology innovation. And thank you, Representative Bonamici, for the introduction.

I study ocean carbon cycles and its boundaries, the sea floor, the sea surface, and the land-ocean margins. Throughout my 20-year career, I've embraced technological development to explore new knowledge and real-world solutions with end users in mind. My work is supportive of and supported by a number of federally funded monitoring programs, including the National Science Foundation Ocean Observatories Initiative, NOAA's Integrated Ocean Observing System, and the National Weather Service, as well as the NOAA and NASA Earth Observing Satellite programs. While each of these programs serve unique objectives, they're being leveraged in the field to drive groundbreaking research in technology innovation.

For today's testimony, I will highlight this—I will highlight an example of my technology innovation that's been particular impactful in the West Coast for shellfish agriculture.

In 2007, shellfish hatcheries that support the commercial shellfish aquaculture industry in the U.S. West Coast began to experience failure in the production of the larval shellfish, the seed that is sold to commercial growers. Commercially available monitoring technology couldn't identify what was happening or how to remedy it. Alan Barton, the Manager at the Whiskey Creek Shellfish Hatchery in Netarts Bay, Oregon, contacted me to pursue linkages between production failure and bay water carbonate chemistry.

My measurement, together with his hatchery production records, identified the environmental trigger for this seed stock crisis. Exposure of larvae in their first few hours to days of life to waters with low favorability for shell development is resulting in stress that dramatically reduced seed growth and survival.

Complexity of this problem and why it demanded new technology solutions stems from the variety of ways carbonate chemistry in natural waters responds to natural and anthropogenic forces. These responses include changes in dissolved carbon dioxide gas, PH, and the favorability of waters for carbonate mineral shell formation, upon which many shellfish rely.

The favorability for mineral formation, also known as omega, cannot be directly measured but must rather be calculated from multiple parallel measurements of carbonate chemistry. In dynamic coastal waters the seemingly simple measurement of PH is far more difficult than widely realized and is itself a poor proxy for the more critical value of omega. The intake water chemistry could

previously only be determined adequately by infrequent and costly discrete samples that could sometimes take months for analysis, leaving hatchery operators blind to the environmental conditions that impacted their operations to the greatest extent.

With technological development, motivated by my own ocean carbon cycle research and supported by grants from National Science Foundation and NOAA, I ultimately developed a system and devised sampling protocols with low cost and skill barriers to develop data systems for routine service sample analyses. These systems allow commercial users to assess real-time carbonate chemistry conditions relevant to the production of shellfish seed stock.

At Whiskey Creek, which was near total collapse in 2007, the installation of the prototype system in 2009 and the development of proper approaches to buffering intake seawater operations allowed the hatchery to begin to recover. Now, Whiskey Creek is back to near total production recovery to pre-crash levels. This work was referred to by former NOAA Chief Scientist Rick Spinrad as the \$100,000 investment that saved a \$200-million-per-year industry.

These systems, first popularized by Netarts Bay oysterman Mark Weigardt as the percolator in reference to the bubbling gas separation chamber, could be produced at a cost well under half that of instruments at the time used in the research community and provided significantly greater capacity for measurement flexibility than any existing technology.

While the price per instrument is still high, the benefit of the knowledge it produces for more efficient commercial operations has been embraced by the shellfish industry on the North American Pacific coast. More than 20 systems have been deployed or are in development for deployment in shellfish production facilities and marine laboratories from Carlsbad, California, to Seward, Alaska. Further commercialization will continue to reduce unit cost and streamline maintenance operations.

The technology has been commercialized via license by Oregon State University to my limited liability corporation and will soon be sublicensed to Sunburst Sensors of Missoula, Montana. In addition, the continued generation of research quality monitoring data serves the working waterfront stakeholder and oceanographic research communities alike.

In summary, while there was urgency among the shellfish industry for a Burkolator technology solution, the market was initially too small to provide motivation to independently develop a market-driven prototype from a purely commercial perspective without the research-driven environmental monitoring technology development that I had already completed.

This federal- and university-supported innovation pathway represents an ideal model for application of research-driven technological development and unique market needs and, ultimately, technology transfer to the commercial sector.

Thank you for the opportunity to testify today on the importance of our federal investment in environmental research, monitoring, and observation systems and research-led technology investigation. I welcome the opportunity to expand on and clarify my comments in response to any questions you may have.

[The prepared statement of Dr. Hales follows:]

Testimony of Dr. Burke Hales
Professor of Ocean Ecology and Biogeochemistry
College of Earth, Ocean, and Atmospheric Sciences
Oregon State University

Before the
Committee on Science, Space, and Technology
Subcommittee on Environment
U.S. House of Representatives

Hearing on
“Leading the Way: Examining Advances in Environmental Technologies”

June 21, 2017

Thank you Chairman Biggs, Vice Chair Banks, and Ranking Member Bonamici for the opportunity to speak to you today to discuss the importance of federal investment in environmental monitoring systems and technology innovation. It is an honor to be with you all to have this important conversation.

I am Burke Hales, Professor in Ocean Ecology and Biogeochemistry in the College of Earth, Ocean and Atmospheric Sciences at Oregon State University. I have degrees in Chemical Engineering and Chemical Oceanography at The University of Washington, and served as a Department of Energy Distinguished Postdoctoral Fellow in Climate Change at Columbia University before joining the faculty at Oregon State University. I have a long record of publication and technical innovation in ocean science research, particularly with regard to ocean chemistry and carbon cycling.

I am a biogeochemical oceanographer, studying the ocean’s carbon cycles at its boundaries: The seafloor, the air-sea interface, and the land-ocean margins. My background is strongly technological. I came to the field of chemical oceanography as a chemical engineer, and applied myself to devising ways to observe the previously unobservable. For example, I devised autonomous robotic systems that made sub-millimeter scale measurements of pH, oxygen and CO₂ in sediments miles below the sea-surface, and developed mathematical physical models to interpret these unique observations (1-6). I also devised solutions to automate upper-ocean towed profiling and sampling devices and developed the analytical systems to capture the high-frequency signals generated by these sampling systems (7-19). Finally, I have combined ocean chemistry measurements with satellite observations to build mechanistic predictive models of carbon cycling in ocean margin waters based on remote sensing (20), and devised ways to assess the decreased occurrence frequency of favorable conditions for early larval shellfish under elevated atmospheric CO₂ (21-22).

Importance of Strategic Federal Investment in Ocean-based Monitoring Systems

My work advances and is supported by a number of federally-funded ocean monitoring programs across several agencies. Data produced by analytical systems I developed is now being delivered to and served online in near real-time by the National Oceanic and Atmospheric Administration's (NOAA) Integrated Ocean Observing System in the Northwest (Northwest Association of Networked Ocean Observing Systems, or NANOOS). I also support ocean mooring systems that provide real-time data to NANOOS and NOAA's Pacific Marine Environmental Laboratory (PMEL) CO₂ program, and are now providing important new meteorological observations in low-data regions of the Oregon Coast to the National Weather Service. Additionally, I work with the National Science Foundation's Ocean Observatories Initiative (OOI) infrastructure off the Oregon Coast to provide validation analyses and time-series sensor measurements for carbonate-system chemistry. In addition to work to support these initiatives, I also make extensive use of the regional observations provided by OOI and NANOOS for my own research. Beyond ocean-based monitoring systems, my work intersects with NOAA and NASA earth-observing satellites which provide critical information in the development of predictive models of ocean carbon cycling with relevance to ocean plankton productivity, carbon sequestration, and acidification. Each of these federal programs and systems are unique, but complimentary.

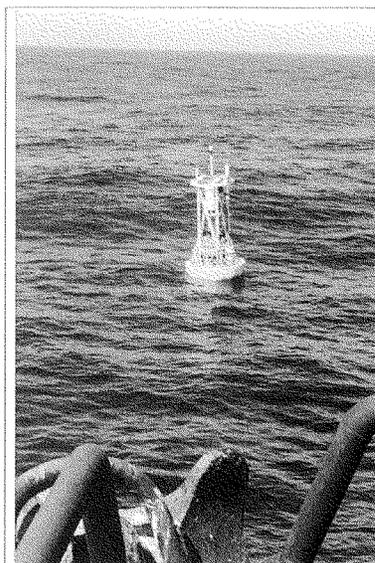


Figure 1. OSU's small-boat serviceable oceanographic mooring, carrying physical, chemical and biological oceanographic sensors and a meteorological sensor array now deployed in a low data-coverage region off Cape Arago on the Southern Oregon coast.

Example of Ocean Monitoring Technology Innovation

I will focus my testimony here to highlight an example of the important role federal investment in ocean monitoring systems and technology innovation had for my work on the Oregon Coast to address a unique industry's concerns for ocean acidification.

It all started when the Pacific Northwest Seedstock Crisis began in 2007. The shellfish hatcheries that support the commercial shellfish aquaculture industry began experience crippling mortality in the larval shellfish, or seed, that is sold to commercial growers (23-25). Commercially available monitoring technology failed to provide a robust environmental link between the

failures and environmental conditions, and commercially-available remediation approaches failed to resolve the issue. It was not until personnel at the Whiskey Creek Shellfish Hatchery (WCSH) in Netarts Bay, Oregon, contacted me to pursue linkages to bay-water carbonate chemistry that the environmental trigger was identified: Low favorability for larval shell development in the first few hours to days of life (23,26), and appropriate remedies for conditioning hatchery intake water were undertaken (25).

Ultimately, I devised a system for the robust constraint of carbonate chemistry of natural waters, popularized by shellfish aquaculturist (aka oysterman) Mark Wiegardt as the 'Burke-o-Lator'.

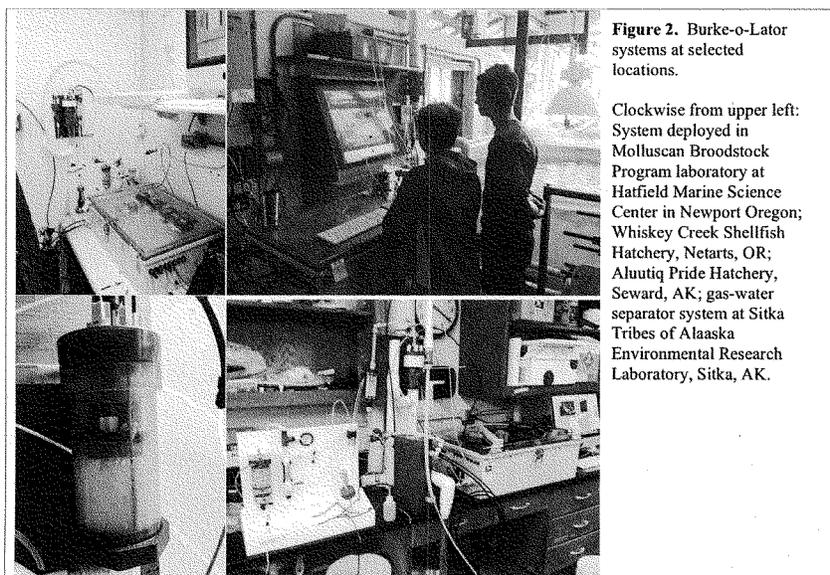


Figure 2. Burke-o-Lator systems at selected locations.

Clockwise from upper left: System deployed in Molluscan Broodstock Program laboratory at Hatfield Marine Science Center in Newport Oregon; Whiskey Creek Shellfish Hatchery, Netarts, OR; Alutiq Pride Hatchery, Seward, AK; gas-water separator system at Sitka Tribes of Alaska Environmental Research Laboratory, Sitka, AK.

This system allowed commercial users to assess real-time carbonate chemistry conditions in the context of production of shellfish seed-stock that supports the commercial shellfish industry on the US west coast (24-25). This system has been commercialized via a license awarded by OSU to my LLC, and will soon be sublicensed to Sunburst Sensors, LLC, of Missoula, MT, a leader in the autonomous measure of natural water pH and CO₂.

Carbonate chemistry in natural waters responds in a variety of ways to natural and anthropogenic forcing, including changes in dissolved CO₂ gas, pH, and the favorability of waters for precipitation of calcium carbonate, the bio-mineral from which many shellfish build their shells and skeletons. This favorability for mineral formation, also known as Ω , cannot be directly measured, but must rather be determined by multiple parallel measurements of carbonate

chemistry and subsequently calculated. In dynamic coastal waters, simple connections between this critically important term and the more easily observable pH are poorly constrained, and the seemingly simple measurement of pH has analytical challenges that are not understood outside of a community of highly-specialized researchers. Without the full constraint of the carbonate system provided by the Burke-o-Lator's parallel measurements of dissolved CO_2 gas and total dissolved carbonates, the system chemistry could only be determined by infrequent and costly discrete samples that could sometimes wait months for analysis. Shellfish hatchery operators were without any tools for timely observation of the parameter that impacted their operation the most.

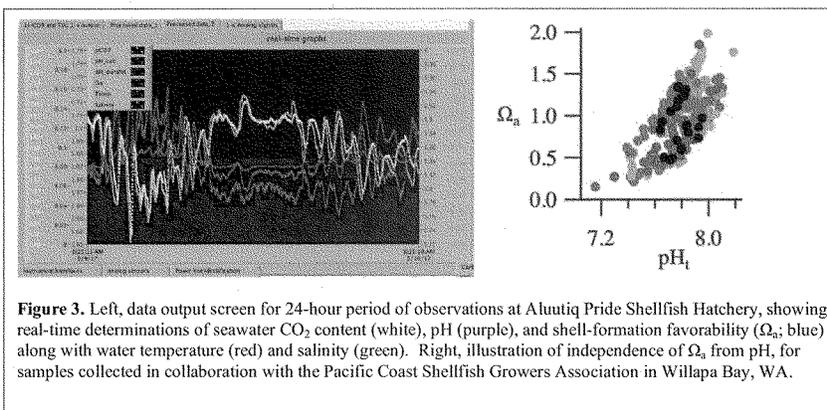


Figure 3. Left, data output screen for 24-hour period of observations at Alutiq Pride Shellfish Hatchery, showing real-time determinations of seawater CO_2 content (white), pH (purple), and shell-formation favorability (Ω_a ; blue) along with water temperature (red) and salinity (green). Right, illustration of independence of Ω_a from pH_t for samples collected in collaboration with the Pacific Coast Shellfish Growers Association in Willapa Bay, WA.

Federal-University Supported Technology Innovation Results in Real-World Impacts

With technological developments motivated by my own ocean carbon cycle research and supported by grants from the National Science Foundation and the National Oceanic and Atmospheric Administration, I was able to develop systems for these measurements that were significantly lower-cost, faster-analysis, and more-robust for dynamic coastal waters than much of the research community, and were unparalleled by any existing technology in the commercial sector.

Given the extensive federal support of the technological development of these systems, it was then only a matter of integrating these measurements into a single system and devising sampling protocols with low cost- and skill-barriers to develop the beta Burke-o-Lator technology systems for routine service sample analyses in my laboratory at OSU and the real-time monitoring of bay-water intake at Whiskey Creek Hatchery. Since that time, systems have been deployed in shellfish production facilities and marine laboratories from San Diego, California to Seward, Alaska. There are currently 20 systems deployed or in the late stages of production, constructed either at OSU or by myself in my garage.

At near total collapse in 2007, the installation of the prototype Burke-o-Lator in 2009 and development of proper approaches to buffering intake seawater began to bring operations at Whiskey Creek back from the brink. In fact, when I asked to take my loaned prototype out on a research cruise that year, WCSH owner Sue Cudd refused, saying, "I'll go out of business if you take that instrument out of my hatchery," and I had to assemble a field instrument from spare parts in my lab to support my core oceanographic research. Now, WCSH is back to near total production recovery to pre-crash levels. While the price per instrument is still high, at \$50,000 per copy, the recurring maintenance cost is significantly lower, and further commercialization will continue to reduce unit cost. In addition, the continued generation of research-quality monitoring data serves the working-waterfront stakeholder and oceanographic research communities alike.

Closing

In summary, while there was urgency among the shellfish industry for a BoL technology solution, there was no motivation to independently develop a market-driven prototype from a purely commercial perspective prior to the research-driven environmental monitoring technology development. The federal and university supported innovation pathway that this Burke-o-Lator technology developed represents the ideal model for technological development for unique market needs, and, ultimately, technology transfer to the commercial sector.

Further, impactful environmental monitoring technology innovation is made possible by the critical investments we make as a society for basic science and the pursuit of new knowledge. Environmental research allows us to constantly push the limits of our current understanding of our oceans, atmosphere, and the earth. This constant expansion of our knowledge allows us to develop high quality data parameters to deploy useful monitoring and observation systems that are beneficial across public and private sector interests.

Federal and state governments, universities, and private sector stakeholders all have a role to play in driving environmental technology innovation for impactful monitoring systems. In the case of the Burke-o-Lator, federal investment supported exploratory technological development when markets for such technology were not yet viable for commercial R&D investment. Then, as knowledge and technology capacity hardens, private-sector commercialization opportunities arise. This innovation pathway can yield commercial environmental technology products that, when applicable, can provide excellent resources for cost-effective monitoring systems.

Thank you for the opportunity to testify today on the importance of our federal investment in environmental research, monitoring and observation systems, and research-led technology innovation. I look forward to further discussion and welcome opportunity to expand on my comments in response to any questions you may have.

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Dr. Burke Hales Biography

Dr. Burke Hales is professor of Ocean Ecology and Biogeochemistry in the College of Earth, Ocean and Atmospheric Sciences at Oregon State University. Dr. Burke holds his degrees in Chemical Engineering and Chemical Oceanography from The University of Washington. He has a long record of publications and service, and has spent approximately 700 days at sea over the course of his career. Notably, he was a lead author on the first State of the Carbon Cycle Report and was the lead editor of the North American Carbon Cycle Report. He has also served as a science judge for the Wendy Schmidt Ocean Health XPrize, which is a \$2 million global competition that challenges teams of engineers, scientists and innovators from all over the world to create pH sensor technology that will affordably, accurately, and efficiently measure ocean chemistry. Dr. Hales current research focus is on coastal ocean carbon cycles; ocean acidification monitoring and experimentation; and, measurement and experimental technology.

Chairman BIGGS. Thank you, Dr. Hales. And I thank each of the witnesses for their testimony.

Members are reminded that committee rules limit questioning of the witnesses to five minutes, and the Chair recognizes himself for five minutes.

Dr. Jacobs, I understand that NOAA currently buys a limited amount of the data you collect. Can you explain the relationship between Panasonic and NOAA? And does NOAA freely distribute your proprietary data?

Dr. JACOBS. The current relationship we have is to sell NOAA a subset of our TAMDAR data through the National Mesonet Program. We do put redistribution restrictions on that data both to other WMO members, as well as open to the commercial market. The reason why we do that is we need the opportunity to sell the data to those other government agencies, as well as business customers. If the data were redistributed openly and freely, then we wouldn't have that opportunity and we would have to build that into the price that NOAA would pay for the data.

Chairman BIGGS. I also understand that Panasonic runs its very own weather prediction model. How does this model compare to our government's model? And do you think NOAA's strategy for technology innovation has slowed their ability to create better weather forecasts?

Dr. JACOBS. Our model is somewhat similar to theirs in the data assimilation component and the dynamic core. A lot of what differentiates it are things we do in the model as far as the physics. There are some other different steps in the data assimilation process. In addition to that, we use not only the observation systems that they assimilate, but we have additional observations that we assimilate into our model as well.

As to their timeline, they're on a pretty robust, slow timeline. I think it's really important for them from my perspective the way I see them operate is worried about up-time and reliability, so having transitions to newer models takes a tremendous amount of testing and sometimes several years to test these new upgrades that they implement.

Chairman BIGGS. And for Mr. de Halleux, I understand you have partnered with NOAA and the Navy to validate some of the data you collect. Is there any indication that the federal government is willing to purchase your data on a longer-term contract?

Mr. DE HALLEUX. This is correct. We currently work with the Navy and NOAA on the assessment of the technology. We have a five-year agreement with NOAA OAR, and we have been working with the Pacific Marine Environmental Laboratory and the Alaska Fisheries Science Center on a rigorous comparison between the data quality collected by the Saildrone vehicles and the existing NOAA assets, in this case, research vessels and buoys. And the assessment has come back positive.

And to answer your question, yes, there is willingness of engaging on the longer-term basis but no defined mechanism for transferring the technology from the lab inside NOAA to the line offices.

Chairman BIGGS. Just—when you say the assessments came back positive, can you elaborate on that just for a minute, please?

Mr. DE HALLEUX. Yes. So, the assessment was essentially a correlation of the data set from existing NOAA assets—ships and buoys—and Saildrone technologies equipped with the same instrument located in the same location during the same time frame. So physically, it's called follow the leader where you have USVs and 500 yards behind a research vessel collecting the exact same data, scientists at NOAA have subsequently analyzed the two different data sets and found the correlation to be, quote/unquote, “outstanding” in terms of the quality of the data.

Chairman BIGGS. In your experience, has working with the government been a fast and easy process? And have you found that the government seriously considers its private partners for anything more than trial periods?

Mr. DE HALLEUX. So, to answer the first part of your question, yes. Our particular experience with NOAA on the research and development side has been outstanding on all accounts in terms of the speed of adoption, the assets that were mobilized for assessing new technologies, and the types of missions we've performed, which have ranged from Arctic exploration to tropical Pacific missions to fisheries research missions.

The second part of your question, the transfer of the technology once the assessment is performed, is kind of the point we are at right now, and there is a question mark as to how the technology gets transferred once it's been assessed and has matured into recurrent operations.

Chairman BIGGS. Well, with that in mind, what can we do better? What—where do we need to get better in—you know, such as in licensing? How do we improve from your perspective?

Mr. DE HALLEUX. So—

Chairman BIGGS. And I'm not—nobody's going to hold you to this. I just—you know, just get your idea.

Mr. DE HALLEUX. It's hard for me to answer that directly. I think the improvement is around both the mandate such as the ones that are given by the Weather Service and, you know, more precisely highlighting the need for public partnerships in those line offices. And there's always, in any scientific organization, reluctance to introduce new technologies because, as you introduce new technologies, you introduce new ways of working.

And what's very important to remember is that these technologies are augmenting existing capabilities. As I was saying my testimony, ships are required for high-capability missions, which require in situ sampling, deployment of assets, things like that. But the unaddressed—what we call the long tail of data collection is what, you know, needs to be taken care of with new technologies. And so defining those frameworks, those public-private partnership frameworks is kind of what's needed to be able to move that forward and with that, you know, the budgets that support those new technologies, which NOAA currently does not have.

Chairman BIGGS. Thank you. Again, thanks to all the witnesses. My time is expired.

I recognize the Ranking Member, Ms. Bonamici.

Ms. BONAMICI. Thank you very much, Mr. Chairman.

And first, I—before I ask you my questions, I want to note that there's a lot of questions being asked today about NOAA. It would

have been helpful to have NOAA as well and testimony from them about working with these different partners, so I hope that in the future we can include NOAA when you're planning a hearing like this where we're asking lots of questions about working with NOAA.

Dr. Hales, you told that great story about the shellfish industry in the Pacific Northwest, and being from the Pacific Northwest, it's very close to home to me, but I want to emphasize that this is an issue that affects people across the country. When they go to a restaurant or a grocery store and want to buy shellfish, they want it to be there. And I know that that was important work and a really great example of how commercial technology can grow out of fundamental scientific research.

And in telling your story, I think you've made it pretty clear that the shellfish growers did not have the tools themselves to adapt to the changing acidity of the ocean. They needed a tool like the Burkolator. And can you answer the question about would you or another researcher have had the time and resources necessary to build that tool without federal funding, the grants through NSF and NOAA?

Dr. HALEES. The short answer is no. Without the prior research-driven support, this work wouldn't have happened. I developed individual components of these systems in response to needs from my high-resolution, high-frequency sampling systems, and when I was contacted by the hatchery industry, most of this work was done on a shoestring with existing technology, spare parts and devising ways to merge those two measurement capabilities in ways that would help the shellfish industry.

Ms. BONAMICI. Thank you. And I know, Mr. de Halleux, and—I hope I was close in the pronunciation—and Dr. Jacobs, I know in your testimony you made it pretty clear that your work is to supplement or to augment, not to replace, the work of NOAA, NSF, the federal agencies. Can you talk a little bit about how the federal government can continue to be an important contributor to technology innovation for the future and what federal investments or incentives are most important to help drive commercialization of research-driven technology and innovation? Go ahead.

Mr. DE HALLEUX. So, it's very important to realize that companies like Saildrone harness the best of the private sector, which is rapid iteration of R&D, to solve complex engineering problems very cost-efficiently, but we are not scientists, and therefore, our only mission is to solve engineering problems to make agencies like NOAA and NASA more efficient from a science perspective. And therefore, you know, the role of—that NOAA plays is a critical one on the science front, and our hope is that, you know, by contribution from the private sector we can accelerate the science to answer questions that further the missions of those agencies.

Ms. BONAMICI. Thank you. And I know we've had conversations in this committee about technology transfer and commercialization, and I hope we can continue those.

Dr. Jacobs?

Dr. JACOBS. I view it as a very good thing to have the opportunity to have a business relationship with NOAA that enables us to have a sustainable model but also allows them to advance their

mission and improve their forecast services to the public. So, I think it's a very—

Ms. BONAMICI. Terrific. Thank you. And again, in this committee we've had a lot of conversations about data quality and quality assurances, and they're a priority, I know, for monitoring systems and supporting technology, whether publicly or privately owned, for research or commercial purposes. So, what role should the federal government have to ensure technology and monitoring systems are providing users with reliable and accurate data? And can you walk us through—I know we don't have a lot of time, but summarize your process for data validation. Dr. Jacobs, would you like to start?

Dr. JACOBS. So, we—this is one reason why we do a lot of internal modeling, because we use our own models to sort of quality control the data. So, there's a pretty elaborate quality control system we have in place that screens the data before we pass it to the Weather Service. We pass along those quality control flags with the data to them.

In addition to that, the FAA also funded a four-year data denial study with the Weather Service to analyze the impact of our data in their models. So, from our perspective, we prefer that NOAA sets the bar for data quality and we have to jump over it.

Ms. BONAMICI. Do you concur?

Mr. DE HALLEUX. We totally concur, and we let NOAA drive the quality definition of both the process and output, and we comply with, you know, all the required processes to assure the quality is there. It's of paramount importance, as you stated.

Ms. BONAMICI. Thank you very much. And my time's about to expire. I yield back. Thank you, Mr. Chairman.

Chairman BIGGS. Thank you.

The Chair recognizes Representative Babin for five minutes.

Mr. BABIN. And I'm from Texas there, Mr. Chairman.

Chairman BIGGS. The gentleman from Texas, yes, sir. I'm sorry.

Mr. BABIN. Thank—

Chairman BIGGS. I should have mentioned that.

Mr. BABIN. Thank you. Thank you very much, and thank the witnesses for being here, too. We appreciate it.

I have several questions for Dr. Jacobs. Does the government take full advantage of the technologies that your company provides in your opinion?

Dr. JACOBS. Currently, no. One of the things that they are—don't have access to in real time are the icing and turbulence data. So, the National Weather Service, through the Mesonet program, acquires the temperature, wind, pressure, and moisture data, but currently, neither the Weather Service or the FAA are receiving the icing and turbulence data.

We do offer to, on a 48-hour delay, make that available, so quite often, the NTSB will contact me to do accident investigations if it was aviation-related to icing or turbulence. But currently, no one sees that data in real-time.

Mr. BABIN. Well, you would think that they would be interested in that information for goodness sakes. Why would the government decline to purchase high-quality weather and aviation data that could save and protect lives?

Dr. JACOBS. My guess is it's budget-related. It's not that they necessarily haven't declined it; it's that they haven't put a solicitation out to receive it. But they are well aware that it exists.

Mr. BABIN. Okay. And then also it appears to me that NOAA is averse to changing things. Time and again, we've seen them move slowly to adopt innovative technologies to better monitor our environment and oftentimes refused to do so without being forced to do it legislatively, a mandate. In your opinion, how do we change the current paradigm so that NOAA can more effectively and efficiently innovate to protect lives and property? And in light of what you just said, maybe it's funding. I assume that we were giving them adequate funding, but let me hear what your opinion is.

Dr. JACOBS. I think a lot of these innovations are rapidly evolving in the private sector, and probably the quickest way to advance NOAA's mission is to harness the capabilities in the private sector and let the private sector probably drive the pace. So, setting up a sustainable business model of public-private partnership between the public sector and private industry would be a pretty way to fast track a lot of the innovations coming out of the private sector.

Mr. BABIN. They also claim that—NOAA also claims to—that they are, quote, an “environmental intelligence agency.” In your opinion, do you think they act as such?

Dr. JACOBS. Defining the word intelligence in a way that means they are observing and sampling the environment, I suppose so.

Mr. BABIN. Okay. Well, does NOAA take full advantage of all the technological innovations to better monitor our environment?

Dr. JACOBS. There are innovations that I'm aware of out there that they are not currently using.

Mr. BABIN. Yes. And then, Mr. de Halleux, can you chime in on some of this as well?

Mr. DE HALLEUX. I think, as I said, that NOAA has—is very good at looking at the technologies available and assessing them. I think it's the transfer and the public partnership framework that is missing and the dedication of imagining the future. So, it's one thing to say that a USV can produce same data quality as a ship. It's another to ask what could the technology do for a budget at scale? You know, what would a global observatory look like using new technologies either on the surface, at high-altitude, or from space? And that capability of planning and roadmapping is not always taking advantage of the private sector innovation.

Mr. BABIN. Absolutely. And, Mr. Chairman, I yield back the balance of my time. Thank you. Thank you.

Chairman BIGGS. Thank you.

The Chair recognizes the gentlelady from Hawaii, Ms. Hanabusa.

Ms. HANABUSA. Thank you, Mr. Chair.

Thank you to the witnesses for being here. As you can imagine, representing Hawaii, all of your different topics are very important to me, especially because if there's any area in the United States that's very susceptible to oceans as well as weather, I'd like to think that it's us more than anyone else.

Having said that, Dr. Jacobs, in reading your testimony, one of the statements that you made that caught my eye and I'd like for you to expand on is on page 3 when you said, “In addition to passenger and crew safety”—you're talking about TAMDAR network—

“significant fuel savings are realized by the airlines, which has the added benefit of greatly reducing the carbon footprint of commercial aviation.” Can you explain that? As you know, nobody gets to Hawaii primarily unless you’re on a plane, so what do you mean by that statement?

Dr. JACOBS. So, this is another reason why we internally run a global model versus relying on NCEP output. We write out the native files from our model on flight levels, and we use the window grid from that to optimize the flight routes on ascent, descent, and cruise. So, if the planes actually have the ability to find more efficient winds to fly through, they can use less fuel, so it’s strictly a cost savings from the airlines’ business perspective, but the added benefit is reduction in CO₂.

Ms. HANABUSA. And is this something that the airlines directly—but the airlines can’t establish their routes, right? I mean, it’s FAA-determined. So, do you sell that information to the FAA or—it seems to be that that’s something that needs to be flexible by wind patterns as opposed to how I assume that they do it, which is to set it and say everybody flies this route. Am I correct?

Dr. JACOBS. They have an option and it really depends on the airspace. For example, in the LaGuardia/JFK airspace, they have absolutely no control over where they fly—

Ms. HANABUSA. Yes, I don’t think they can move.

Dr. JACOBS. —but there are quite a few areas, particularly at cruise level, where they have choices where they can fly either east or west over the pole or they can fly a higher latitude or lower latitude based on the position of the jet stream. And they can also choose different flight levels. But they still have to request that through ATC before they can file that plan.

Ms. HANABUSA. I was going to say I think one of the issues that this Congress faced last year was the whole issue of how they would handle ATC, and it would seem like one of the critical issues there was how updated that equipment was. And I’m very curious about all these paper things that they put next to their radar so I’m not quite sure, so safety, I would assume, would be part of this discussion as well. So, Dr.—is it de Halleux?

Mr. DE HALLEUX. de Halleux.

Ms. HANABUSA. de Halleux. I was very curious because you do DOD-related research, and as you can imagine, DOD is a very critical part of my State. And I also sit on Armed Services. The Sairdrone is a fascinating technology. I’m curious that when you gather information for the DOD using Sairdrone, you know, we’ve dealt before with the whole concept of dual use in terms of the technology that’s gained. Do you have those issues with the information that you collect for DOD, or is that something that’s exclusive within their jurisdiction?

Mr. DE HALLEUX. So, thank you for pointing out the multi-mission capabilities of the platform. You’re absolutely correct. As a platform, it can take both meta-ocean data collection while it’s performing intelligence mission, whether it’s traffic detection or others. And at the moment this is not fully exploited by DOD, although I would point out that DOD have their own meta-ocean data collection needs. It has certainly been explored extensively by NOAA where the last mission we had six different internal cus-

tomers from identifying waves to collecting meta-ocean data to tracking marine mammals to traffic detection. So, multi-mission capability is a possibility. It's not fully harnessed yet specifically by DOD.

Ms. HANABUSA. But that would be a natural for the Saildrone?

Mr. DE HALLEUX. Absolutely. All instruments run at all times, and therefore, it's a possibility.

Ms. HANABUSA. Do they have any issues with U.S. security of the data collected?

Mr. DE HALLEUX. One of the first missions was to integrate and to look at the security framework of the data, and it's not been fully integrated into DOD frameworks for this application.

Ms. HANABUSA. Thank you very much.

Mr. Chair, I yield back.

Chairman BIGGS. Thank you.

I recognize the gentleman from Indiana, Mr. Banks.

Mr. BANKS. Thank you, Mr. Chairman. And thank you for holding this Committee hearing this morning.

This subject is of particular interest to my district in northeast Indiana where we have one company, for example, Harris Corporation in Fort Wayne that has roughly 450 engineers and scientists making the world's most advanced weather and environmental satellite instruments for NASA, NOAA, and international customers. And as we examine the opportunities in the private sector to partner with the federal government on opportunities in the future, this hearing brings to light several important issues that we should examine further.

And to take off—from where my colleague from Hawaii started a moment ago, my question for you, Mr. de Halleux, is you work with both NOAA and DOD. Can you expand a little bit on some of the differences in attitude or culture and how you develop your relationship with both of those federal entities?

Mr. DE HALLEUX. So, with both we follow the similar process, which was, number one, appropriately assessing the technology by defining standards of quality. And on the case of DOD it's around intelligence. In the case of NOAA, it's about environmental variables. And the differences seem to appear that DOD is better equipped at transferring operationally assessed technology into operations by linking the technology with the capability with a need than NOAA seems to be, although the desire from both sides to use the technology is strong.

Mr. BANKS. So, take that a step forward. What can NOAA learned from DOD?

Mr. DE HALLEUX. I think that studying the capability and trying to plan how to use the capability in an operational setting and ultimately, you know, finding the budgets to operationalize it is something that the DOD is very good at and potentially NOAA could be inspired by.

Mr. BANKS. Any specific processes, programs that you've dealt with the DOD that could be replicated at NOAA that come to mind?

Mr. DE HALLEUX. I think, you know, the idea is to move from a research budget line to a program of record, which in NOAA-speak is being embedded into a line office and finding a partner or an in-

ternal customer into the line office. That process specifically is something which is part of this public-private partnership framework I was talking about. To be very specific, if the OAR labs assess the technology as fit for fish stock assessment, the fisheries organization at NOAA needs to be identified as an internal customer and pick up the technology for operation and develop integrated survey plans so that the technology can be operationalized.

Mr. BANKS. Is it—do you think at NOAA—is it an attitude or a sentiment that makes it more difficult to get to that recognition of the valuable partnership?

Mr. DE HALLEUX. The big difference is that NOAA functions on appropriations whereas DOD has bigger discretionary budgets, and I think that's—you know, that's the difference as we live it. And there is no budget available for the transition, and so the risk approach is more conservative because one technology has to displace another or gets further appropriated.

Mr. BANKS. How many years have you worked with both NOAA and DOD?

Mr. DE HALLEUX. Two-and-a-half years for NOAA, a year-and-a-half for DOD.

Mr. BANKS. Okay. Dr. Jacobs, per your testimony, it's my understanding that there's been some interest from the government to partner with your company on your weather model. Can you describe where those conversations are at this point?

Dr. JACOBS. There's a couple different fronts. Some of it deals with data assimilation, quality control, various physics schemes that we're using in our global model. There's also some modules that are being developed communitywide for dynamic cores. It's not really a scientific conversation as much as a business model conversation from our perspective. And what we're dealing with internally as far as the cost-benefit analysis is—the Weather Service has a—there's—the weather enterprise is basically divided into two groups. There's commercial companies that provide data and services to help the Weather Service further their mission, and then there's companies that use inset-produced model output to derive data and products.

And in Panasonic's case, we compete against those companies on the backend. However, if we were to license any type of co-development to help the Weather Service improve their model, we would by default be improving the products of our competitors, which use inset-produced model outputs, so we're struggling with how to make that balance work.

Mr. BANKS. Very good. Thank you very much. I yield back.

Chairman BIGGS. Thank you.

I—the Chair recognizes the gentleman from Louisiana, Mr. Higgins.

Mr. HIGGINS. Thank you, Mr. Chairman. I have several questions.

Gentlemen, thank you for being here.

Dr. Jacobs, just earlier today at the International Supercomputing Conference in Frankfurt, Germany, The Weather Company, which is an IBM business, announced a plan to improve weather prediction globally via new collaboration with the University Corporation for Atmospheric Research and the National Center for At-

mospheric Research. This represents to me an exciting representation of an era of new technologies emerging every day.

As a representative of a private sector company yourself who's developed its own weather forecasting model, quite successfully I might add, can you speak to the importance of this news? How welcome is competition in your industry?

Dr. JACOBS. I think this is very exciting news. There's actually several companies that are beginning to run their own global weather models. One of the distinctions that I would like to point out, though, is that running a global weather model is not particularly the most sophisticated step in the process. The way the process works is you collect observations globally, including satellite data. You quality-control it. Then, you do this step called data assimilation. This is the part that you need \$100 million supercomputers to produce the initial condition start file. Then, that file is used to initialize a global weather model, which in some cases you can run on a laptop.

What Panasonic does is the entire process from observing systems all the way to the model. What most of these other companies are doing, which I still think it's fantastic, is downloading the start file produced by the National Weather Service NCEP and using that to initialize the model. That sort of gets these companies out of having to do a lot of the data assimilation process, which is actually the one that's computationally expensive to produce.

Mr. HIGGINS. Regarding harvesting data, Mr. de Halleux, I'm very interested in the transition gradually to unmanned surface vehicles. That was a fascinating slide that you presented. Let me ask, how many are currently deployed and where?

Mr. DE HALLEUX. So, we currently have 20 vehicles, and they are all in—under research contract with NOAA as part of OAR and other research with the DOD. We are currently—we triple the production facility and we're planning to be producing one a day.

Mr. HIGGINS. And they are collecting live data right now?

Mr. DE HALLEUX. They're collecting live data, yes, they are.

Mr. HIGGINS. And is—are these SUVs protected from hacking? Data collection can impact international narrative on sometimes rather contentious subjects like climate change, global warming.

Mr. DE HALLEUX. So, the hacking protection and data security is paramount, and as I was saying, for the DOD, one of the first steps was to secure the data path from the vehicle to Iridium back to shore, so the answer is yes. On NOAA's side, data security is a wider topic, and the data—the concern there is to make the data publicly available for research—

Mr. HIGGINS. But you feel like the vehicles themselves are protected from—at the collection site—

Mr. DE HALLEUX. At the collection site, one of the—

Mr. HIGGINS. —they're protected from hacking?

Mr. DE HALLEUX. So, from—in general, which is—and vandalism overall, which is how NOAA describes the problem, which is a big problem for government assets, which has buoys, which get vandalized by fishermen—

Mr. HIGGINS. Right.

Mr. DE HALLEUX. —and then taken for scrap metal, the fact that we are not on a chart and we are very hard to see and we have very low rate of signature, it protects them from—

Mr. HIGGINS. That's a valid point. If I could, Mr. Chairman, it's been mentioned today of NOAA's budget and why they're not perhaps pursuing private technologies more fully. What I would ask this panel, isn't this problem more related to the increasing budgets for NOAA's satellite and ship programs? Is this—isn't this a major hurdle that needs to be overcome? Any member of the panel? In other words, we have to protect the people's Treasury, and there's been some discussion regarding NOAA's not pursuing private technologies, but NOAA's increased budget for satellite and ship programs seems to be in the way. How would you suggest that this panel would recommend we move forward with that?

Mr. DE HALLEUX. I think it's not so much an increase in budget, although you know more budget allows more technology for sure. I think the question is what is the technology mix to achieve specific mission objectives? And as we show today, some mission objectives are not reached because of, you know, potentially not being—using the optimal mix of available technologies.

Mr. HIGGINS. Mr. Chairman, if you would indulge me, I have another question.

Chairman BIGGS. Without objection.

Mr. HIGGINS. If you don't mind, thank you, sir.

And this relates to perhaps the gentlelady, my colleague from Hawaii may be interested. The Fukushima nuclear disaster, they're still dealing with tons and tons, hundreds of tons daily of contaminated water. There's some discussion they're having a problem containing it. You know, they're running out of room, means by which to contain it. And there's some discussion regarding dumping that nuclear—that radioactive water into the Pacific Ocean. Are your vehicles, are your technologies, sir, from Panasonic, your unmanned vehicles capable of measuring radioactive contamination?

Mr. DE HALLEUX. So, we are engineers, not scientists. We can carry a payload anywhere for very long periods of time at very low cost. So, if—I believe there are instruments which can perform the assessment you mentioned. In this case, we can, you know, deploy them. We do not run the science or the instruments themselves.

Dr. JACOBS. Our probe has capacity into it to host additional sensors for chemical, biological, and radiation measurements. This would be particularly useful on the UAV version—

Mr. HIGGINS. Are you currently deployed in the Pacific Ocean near Japan?

Dr. JACOBS. No.

Mr. HIGGINS. Mr. Chairman, thank you for indulging that question. I think that this subcommittee in particular should be quite concerned regarding technologies deployed to measure that potential hazard for the entire world.

Chairman BIGGS. Thank you.

The Chair recognizes the gentleman from Florida, Mr. Posey.

Mr. POSEY. Thank you, Mr. Chairman.

Mr. de Halleux, in your testimony, you stated that drones could drive down cost of NOAA data collection activities by 90 percent. You also agree with NOAA's assessment that it is a fallacy to as-

sume that technology can replace ships in conducting NOAA's work obviously. In your estimation, how much of NOAA's weather data collection activities could be replaced by private sector drones right now? What kind of cost savings do you think could be realized from that?

Mr. DE HALLEUX. Thank you for the question. So, NOAA, as you know, has 16 research vessels and survey ships, of which 8, according to NOAA, are due to be retired in the near future and therefore makes it very hard to fulfill the mandate because if you want to deploy any type of capability, even pushing a simple instrument—you know, for example, to assess fish stock over the Bering Sea, you need a full research ship to do this.

In those cases where the only capability required for mission is pure data collection, then USVs are uniquely qualified to perform those missions at the 90 percent cost efficiency, \$2,500 per day versus \$35,000 per day. But for missions which require high capabilities, including in situ sampling of fish or water or complex onboard analysis, you will always require a ship, and this is where we agree with the fact that the mix does need to include ship as the bedrock of observation.

Mr. POSEY. Some of us that watch the History Channel see some ships that appear to be NOAA crafts used by treasure hunters and other nongovernment entities. Does the government get reimbursed for that?

Mr. DE HALLEUX. I'm not qualified to answer that question. I don't have the facts.

Mr. POSEY. Okay. What rationale does NOAA give for not utilizing private sector capabilities?

Mr. DE HALLEUX. Those capabilities have been part of NOAA's fleet plan for a while. There is a mention of USVs as a contingency measure. And up until now, I believe there was no technology that fulfilled the operational needs of NOAA, which have assessed a range of different capabilities. And Saildrone seems to be one of the first companies that passes the threshold, and there is a strong desire inside NOAA to use more of that technology pertaining to problems that we mentioned in the past, which is, you know, questions around the public partnership framework and the availability of budgets for those new technologies.

Mr. POSEY. Thank you. Assuming data collection drones from industry become increasingly more capable in the future, what percentage of NOAA's activities would you estimate could be replaced by entirely unmanned systems in the next, say, 5 to 10 years?

Mr. DE HALLEUX. Again, you know, over the next 5 to ten years, NOAA estimates that half the fleet will simply be out of commission due to its age, so that's a number, you know, even irrespective of joint technology which is to be considered.

The second factor to consider is that the mission and the scope of the mission is increasing all the time as, you know, the complexity of the system monitoring and the data collection effort increases. So, I cannot give you a precise number. What I can tell you is that you can deploy a global service observation system on a 6-by-6-degree resolution with about 1,000 drones. And in comparison, there is such a network that already exists subsurface called the Argo network, which uses 3-by-3-degree resolution with close to

4,000 deep-ocean vehicles. So those things have been done. There is precedence for deploying unmanned technologies and to answer very important questions. Now, does NOAA want to envisage this kind of future remains to be discussed.

Mr. POSEY. Thank you, Mr. Chairman. I yield back.

Chairman BIGGS. Thank you. I thank each of the witnesses for your very interesting testimony and the Members for their questions as well.

The record will remain open for two weeks for additional comments and written questions from Members.

This hearing is adjourned. Thank you.

[Whereupon, at 11:07 a.m., the Subcommittee was adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Neil Jacobs

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT**

“Leading the Way: Examining Advances in Environmental Technologies”

Neil Jacobs, Ph.D., Chief Atmospheric Scientist, Panasonic Avionics

Questions submitted by Environment Subcommittee Ranking Member Suzanne Bonamici

1. Is there ever an incentive for the private sector to make investments in research where their bottom line is not a primary consideration?

Financial incentive is the fundamental driving force behind all progress made in private industry; however, it is not always the *primary* consideration, so the answer would be yes. Ultimately, investments in research from private industry are made with the expectation of receiving a return on that investment (ROI). Otherwise, the investing business will fail. This is the reason to make the distinction between *applied* and *basic* research.

I would define basic research as that which has no clear ROI path. Certainly, the knowledge gained may be critical to humanity at some point in the future, but at the time it was funded, it was merely a question with no answer. Private industry does not normally invest unless they see a way to monetize the findings. Thus, there will always be a need for federal funds directed towards *basic* research.

Ancillary benefits, despite being secondary motivating factors, often result in greater benefits to society than the initial profit motive. For example, Panasonic funds research at the university level. Not only does this provide support for faculty and students, many of which will use their education to benefit society, but these funding sources also reduce the competition in academia for federal funding, therefore providing additional funding opportunities for other faculty and students in unrelated fields.

Another example, which is specific to Panasonic, is our flight route optimization. This product is strictly a fuel-savings product. The airline's primary incentive is cost-savings based on fuel consumption. The ancillary benefit is that this product saves, on average across a 100-plane fleet, 45,000 tons of CO₂ per year, which many would consider a primary benefit.

2. Should the federal government continue to make investments in experimental research technologies even if the private sector elects not to?

As stated above, basic research, with no clear ROI path, will

always be reliant on funding from the federal government. If the weather enterprise can devise a business model that creates an incentive for industry to fund more applied research, it should result in more basic research getting funded because it reduces the pressure on federal funding sources.

If the private sector elects not to invest, there are likely two potential reasons: 1) the technology is still in its infancy (basic research) stage, or 2) the technology is mature, yet some other hurdle exists that is preventing it from becoming a viable solution.

In the case of (1), this is a clear justification for federal research funding; however, in the case of (2), it may be wise to have an open public-private dialogue to discuss the reasons for lack of private investment interest. Ideally, this dialogue would shed light on the limitations and hurdles, and thus, prevent federal research monies from being needlessly spent on mature technologies with no possibility of becoming a self-sustaining solution in the future.

Yes, the federal government should continue to make investments in experimental research when the private sector elects not to, and after it is understood why the private sector elected not to.

3. Can Panasonic's weather monitoring capabilities fully supplant the existing federal weather monitoring and observations infrastructure?
 - a. Why or why not?

All of the observing systems, solutions, monitoring, modeling, prediction, and forecasting infrastructure exist in the private sector. While it is technically possible, the *why or why not* is more a function of constructing a logical business model that justifies it.

- b. Should they?

In light of growing federal budget constraints, it would be a cost-effective solution for the federal government to harness the advancement of private sector innovation in weather monitoring and prediction. Ideally, a public-private sustainable business relationship would be constructed that would enable the public sector to further advance their mission of protecting life and property, while at the same time, creating a financial incentive for private industry to partner with the federal government. As it stands now, with the exception of a

few standout programs (e.g., the National Mesonet Program), many areas of the private weather industry find themselves in a competitive situation with the federal government, which is counterproductive to both sectors.

4. What new challenges would such a fully private sector data collection model present to users such as federal agencies, and the public?

The primary challenge would be finding a way to enable federal agencies to further their mission of protecting life and property, while simultaneously protecting the intellectual property (IP) that is generating a profit (i.e., incentive to invest) elsewhere in the market.

For example, free and open redistribution of private sector data would eliminate the ability to resell said data to other entities. Having the ability to sell data to more than one customer means the costs are spread out across many customers, thereby saving each individual customer (e.g., the federal government being one) money.

The inability to recover costs is a deterrent for private sector investment. This would be the single largest challenge, and can easily be overcome by restructuring the redistribution policy of data in a way that allowed for an expanded customer base to share the cost of data production and acquisition.

Responses by Dr. Burke Hales

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT**

"Leading the Way: Examining Advances in Environmental Technologies"

Burke Hales, Ph.D., Professor, Ocean Ecology and Biogeochemistry, College of Earth, Ocean and Atmospheric Sciences, Oregon State University

Questions Submitted by Environment Subcommittee Ranking Member Suzanne Bonamici

- 1. Before the shellfish industry reached out to you, the commercial market was not driven to finance the development of a technology solution for Oregon's shellfish farmers.**
 - a. Since the technology for the Burke-o-Lator was developed with support from federal funds, and with university support instead, how would you describe the return on investment for this work?**

The initial Burke-o-Lator technology development took place over several years, motivated initially by basic research questions regarding the ocean carbon cycle, funded by the National Oceanic and Atmospheric Administration (NOAA) and the National Science Foundation (NSF). Underlying technology innovations to address broader ocean chemistry monitoring needs were then able to be translated into a specific tool for the Pacific Northwest Shellfish Hatcheries with an incremental funding investment of \$100,000 that saved a \$200 million per year industry. This impact highlights the important role of public investment in science and related technology innovations to make direct and exponential impacts on our society and economy.

In summary, the initial technology innovations were a result of efforts to study the detailed structure of carbonate chemistry viability in the Ross Sea near Antarctica in the late 1990's, as well as the coastal waters off of Oregon and New England in the 2000's. The initial demand for the underlying technology was to allow for high-quality measurements of the complete carbonate-chemistry system in sea water. This initial public investment for the underlying technology was itself a successful outcome, and advanced public knowledge through dozens of peer reviewed scientific publications. Then, during the Pacific Northwest Shellfish Seedstock Crisis in the late 2000's, outreach from oyster growers identified the need for a specific technology solution to understand this situation. Effectively, the Burke-o-Lator is the product of incremental innovative work to combine two measurement systems into an automated, real-time output monitoring system. With the information that the Burke-o-Lator monitoring systems provide and the increasing adoption of this system into aquaculture facilities from Carlsbad, California to Seward, Alaska, this modest federal investment for technology innovation has helped to support the Pacific Northwest Shellfish Hatcheries ability to reverse the seedstock crisis.

- b. What is your perspective on whether this technology may lead to new commercially-driven innovation to achieve new cost-efficiencies and opportunities in the future – even considering the unique and niche nature of this market?**

The usefulness of this technology has made it clear that shellfish aquaculturalists need to monitor the chemistry of the waters in which the larval shellfish are grown to understand how favorable conditions are for the production of calcium carbonate. The term 'omega' describes this favorability, and it is currently not a directly measurable parameter of the carbonate system. Omega must be calculated from two independent measurements, which is done by the Burke-o-Lator. Looking forward, the need for systems like the Burke-o-Lator to monitor omega can be expected to motivate development of new sensors and/or systems that achieve increasing cost efficiencies.

