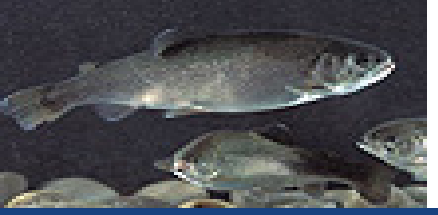
USDA ARS Research in Salmonid Aquaculture



ARS ROLE

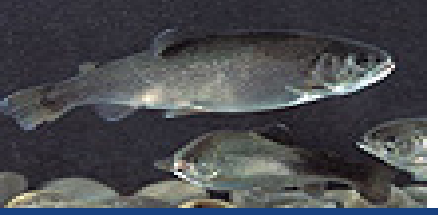
- Inherently Federal
- Work with stakeholders to identify constraints to improving production, production efficiency, product quality, healthfulness, sustainability and/or animal welfare that we have the resources and expertise to address
- Develop science based approaches that complement industry efforts and capacity for problem solving
- Conduct Research and Technology Transfer
- Focus on pre-competitive research that can be facilitated through partnering, including public-private partnerships
- Accountability for taxpayer funds spent on projects

RESEARCH PRIORITIES

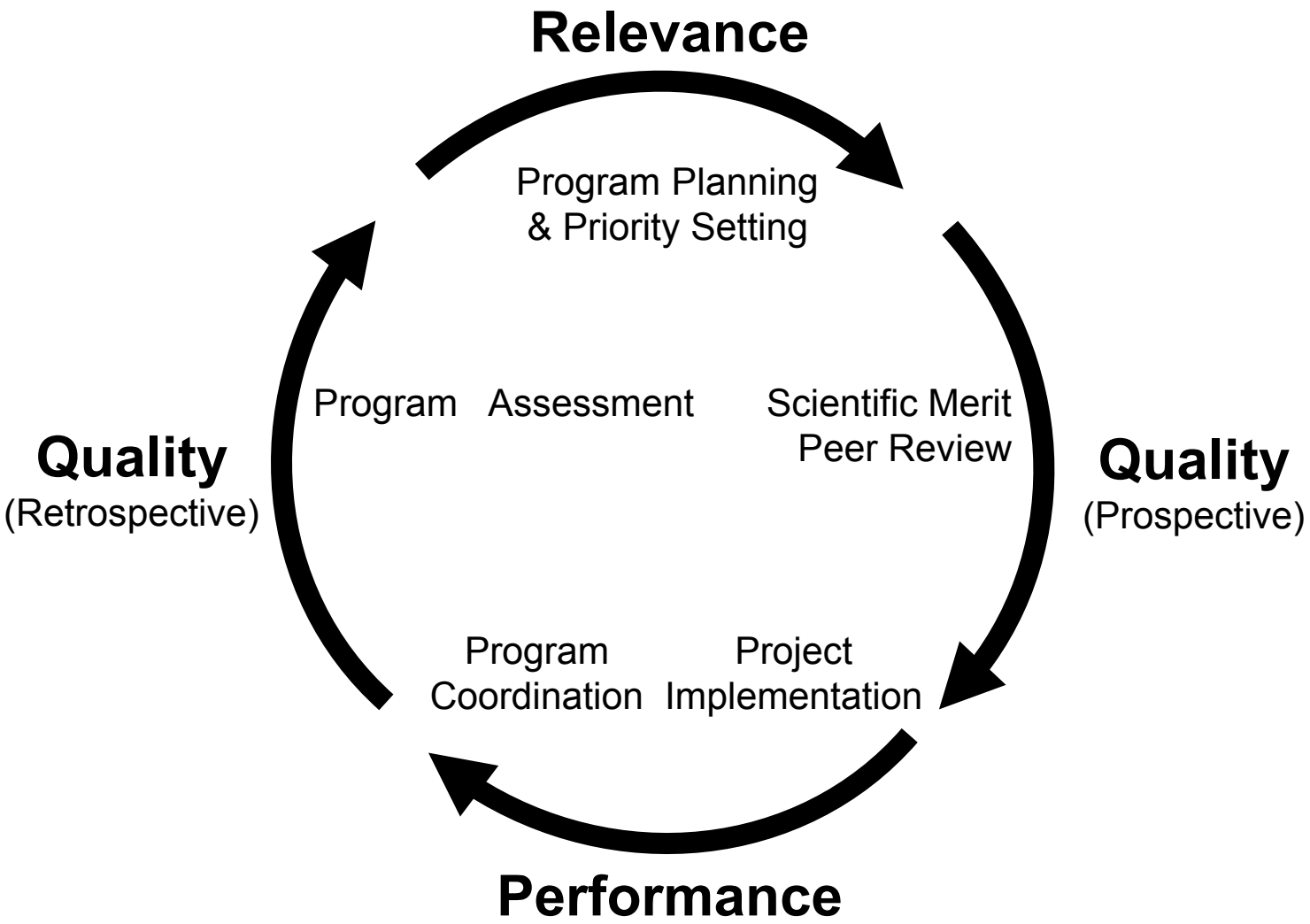
- Presidential and Secretary Initiatives

- Congress

- Customers/Stakeholders
  - Producers
  - Support Industries
  - Allied Organizations



ARS National Program Cycle



ARS AQUACULTURE

Mission: To conduct high quality, relevant, fundamental, and applied aquaculture research, to improve the systems for raising domesticated aquaculture species, and to transfer technology to enhance the productivity and efficiency of U.S. producers and the quality of seafood and other aquatic animal products.

- 1/16 NATIONAL PROGRAMS
- 13 “PERMANENT” PROJECTS
- 47 SCIENTISTS
- ~9 FUNDED COLLABORATORS
- 10 LABORATORY SITES
- BUDGET: ~$28.3 MILLION INTRAMURAL
  ~$.4 MILLION/YR EXTRAMURAL
- FRESHWATER AND MARINE SYSTEMS

FOOD PRODUCTION SYSTEMS

G x **E** x **M** x **P** x **S**

Genetics

Domestication
Selective Breeding
Chromosome Set Manipulation
Hybridization
Monosex
Gene Editing

Environment

Production System – Net Pens, RAS, Ponds, Tanks, Raceways
Water Quality
Temperature
Photoperiod
Microbiome …

Management

Biosecurity
Fish Health
Stocking Density
Nutrition …

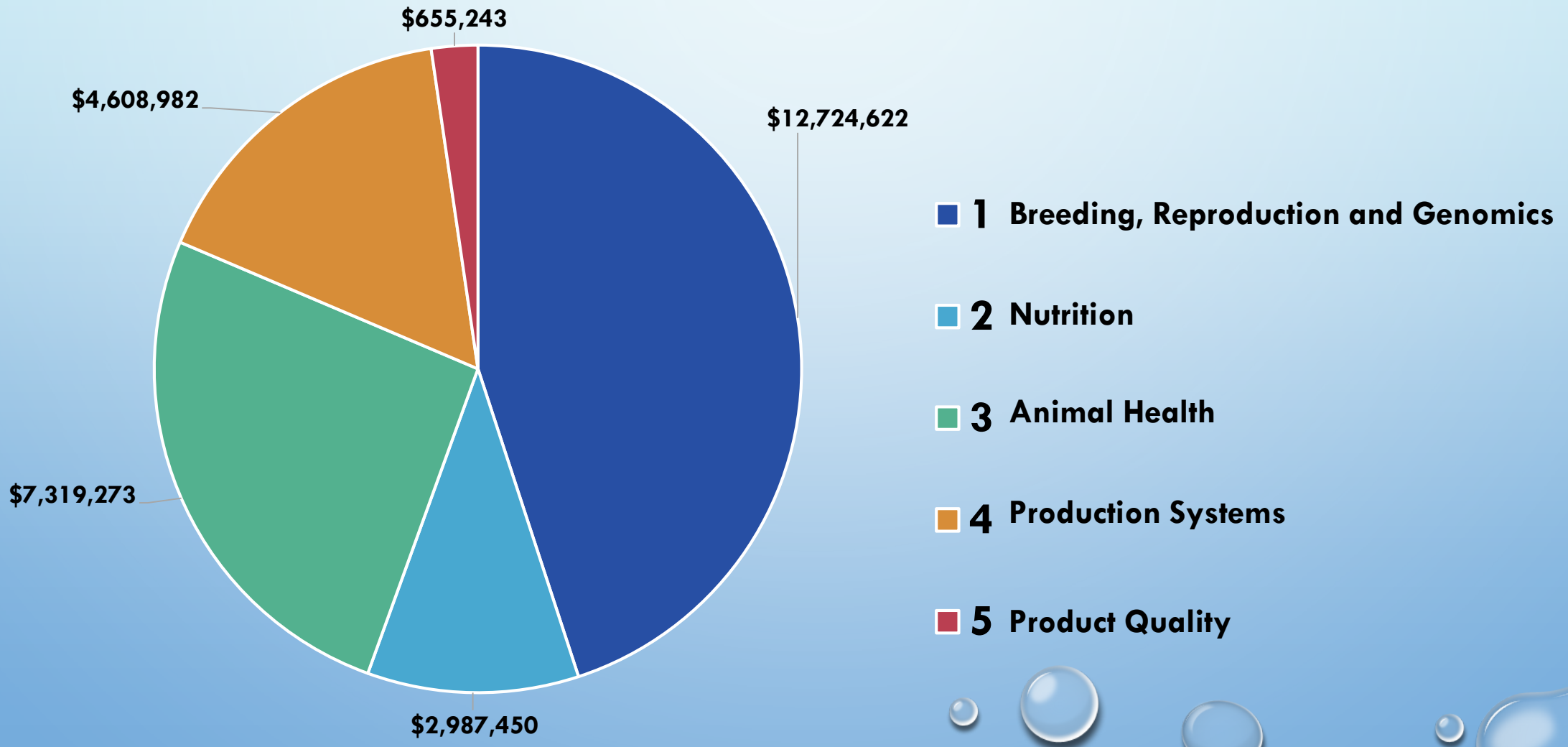
Post Harvest

Product Quality
Food Safety,
Healthfulness …

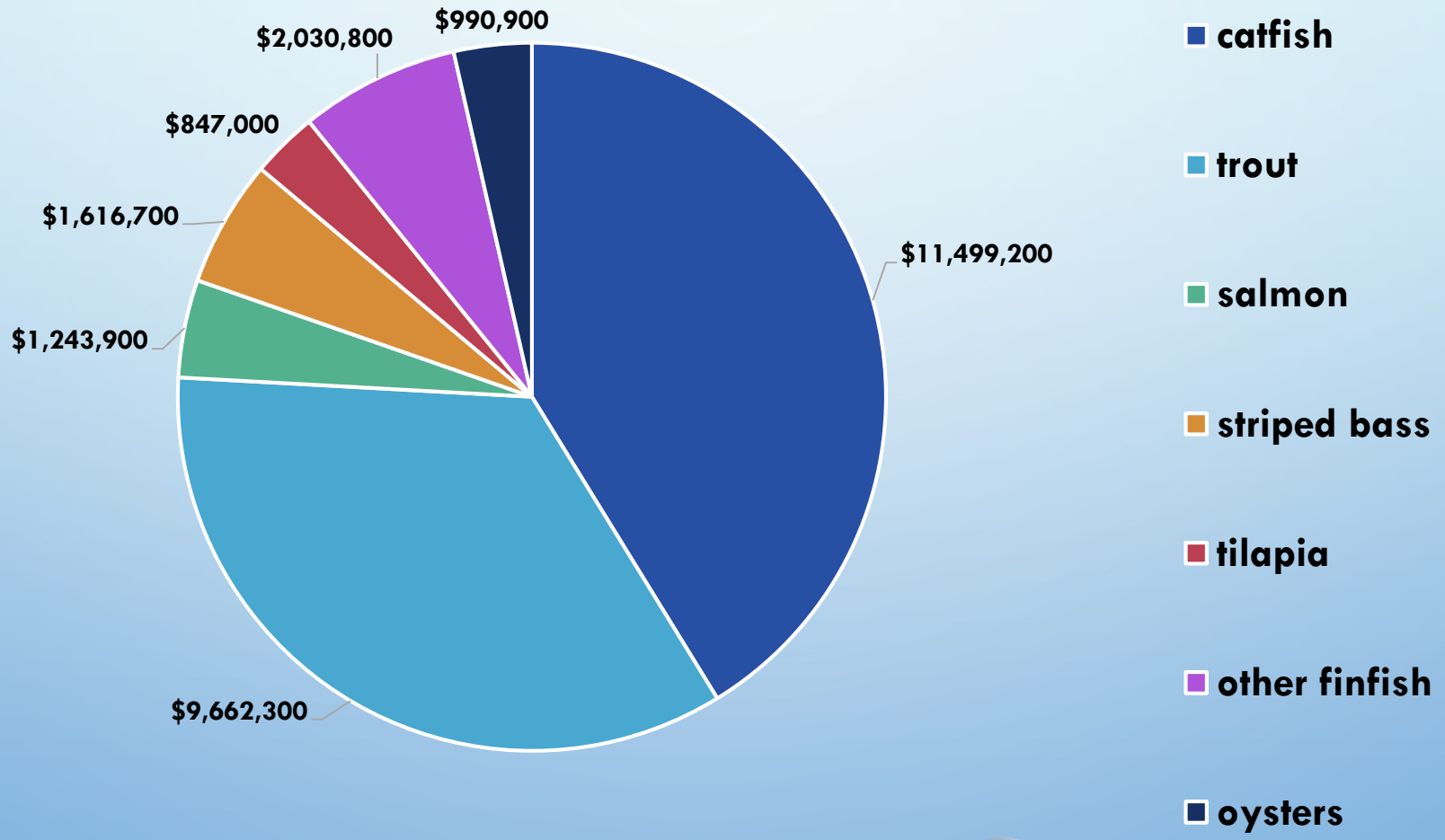
Social factors

Consumer Values
Economics
Marketing …

Estimated ARS Aquaculture Research Annual Investment by Component



Estimated ARS Aquaculture Research Annual Investment by Species



2018 RETROSPECTIVE PANEL

HTTPS://WWW.ARS.USDA.GOV/ANIMAL-PRODUCTION-AND-PROTECTION/AQUACULTURE/DOCS/RETROSPECTIVE-REVIEW-PANEL-EXECUTIVE-SUMMARY/

- DR. ROBERT IWAMOTO, CHAIR
  - RETIRED
- DR. IRENE SALINAS
  - UNIVERSITY OF NEW MEXICO
- DR. CRAIG SULLIVAN
  - CAROLINA AQUAGYN
- DR. PAUL BROWN
  - PURDUE UNIVERSITY
- MR. RUSS MCPHERSON
  - HARVEST SELECT
- MR. DUANE FAGERGREN
  - CALM COVE OYSTER CO.

PANEL DOCUMENTATION

- PRESENTATION – PROGRAM INFORMATION, SUMMARY INFORMATION, SAMPLE ACCOMPLISHMENTS
- ACTION PLANS 2010-14, 2015 – 2019
- PROGRAM SUMMARY INFORMATION
- RETROSPECTIVE ACCOMPLISHMENT REPORT AND REVIEW
- PUBLICATIONS
- ACCOMPLISHMENTS
- TECHNOLOGY TRANSFER
- NATIONAL PROGRAM ANNUAL REPORTS 2013 – 2017
- ARS MAGAZINE JANUARY 2018

ARS AQUACULTURE PUBLICATIONS 2013 - 2017

Publication Type	Number
Abstracts	302
Book Chapters	25
Other	10
Patent Applications	3
Peer Reviewed Articles	519
Popular Publications	20
Proceedings	35
Reviews	6
Trade Publications	32

Fiscal Year	Number of Patents Filed	Number of Inventions Patented	Number of Active Cooperative Research and Development Agreements	Number of Material Transfer Research Agreements	Number of publications published
2013	0	0	1	0	191
2014	4	0	2	28	219
2015	0	2	2	24	187
2016	0	0	1	13	180
2017	0	1	1	10	138

EXAMPLES OF PANEL FEEDBACK

- *FOR THE MOST PART ADDRESSED THE PROBLEM STATEMENTS IN EACH COMPONENT AND SUCCESSFULLY MET THE CHALLENGES OF DELIVERING ANTICIPATED OUTCOMES OUTLINED IN THE ACTION PLANS.*
- *AS A WHOLE, THE PANEL AGREED THAT THE PROGRAM HAD ACCOMPLISHED ITS RESEARCH MISSION EXCEPTIONALLY WELL, PARTICULARLY IN THE AREAS OF GENETICS AND FISH HEALTH.*
- *THE FISH NUTRITION PROGRAM LACKED CONSISTENCY IN INNOVATION FROM THE BEGINNING (VERY INNOVATIVE AND RELEVANT RESEARCH) TO THE END (LESS INNOVATIVE AND RELEVANT) OF THE REVIEW PERIOD.*
- ***THE SUSTAINABLE PRODUCTION SYSTEMS PROGRAM AREA HAS DONE ITS WORK CONSISTENTLY WELL WITH HIGH MARKS FOR RELEVANCY BUT WITH LESS INNOVATION THAN POSSIBLY NEEDED FOR INDUSTRY TO KEEP ADVANCING.***
- *FOR PRODUCT QUALITY/NEW PRODUCTS, THE PANEL FELT THAT, ALTHOUGH THE PROGRAM AREA MADE SIGNIFICANT ADVANCES IN OFF-FLAVOR PREVENTION AND DETECTION AS WELL AS PRODUCT ATTRIBUTES, THERE WERE SEVERAL PROJECTS THAT LACKED RELEVANCE AND PRACTICALITY.*

ARS RETROSPECTIVE REVIEW

https://www.ars.usda.gov/animal-production-and-protection/aquaculture/docs/retrospective-review-panel-executive-summary/

1A Genomics	HIGH IMPACT
1B Breeding	HIGH IMPACT
1C Reproduction	HIGH IMPACT
2 Nutrition	MEDIUM IMPACT
3A Fish Health	HIGH IMPACT
3B Disease Prevention	MEDIUM-HIGH IMPACT
4A RAS and Flow Thru System	HIGH IMPACT
4B Pond Production Systems	HIGH IMPACT
4C Shellfish Production Systems	MEDIUM-HIGH IMPACT
5 Product Quality and New Products	LOW-MEDIUM IMPACT

2018 USDA Aquaculture Listening Sessions

- Salmonids – July 24th, 1pm – 4pm eastern
- Catfish – July 25th, 1pm – 4pm eastern
- Freshwater Finfish, July 26th, 1pm – 4pm eastern
- General Aquaculture, Aug 14th, 1pm – 4pm eastern
- Molluscan Shellfish, Aug 15th, 1pm – 4pm eastern
- Production System, Aug 16th, 1pm – 4pm eastern

Gene Kim, USDA NIFA National Program Leader, Gene.W.Kim@nifa.usda.gov
Caird Rexroad, USDA ARS National Program Leader, Caird.RexroadIII@ars.usda.gov

2018 USDA ARS AND NIFA SALMONID LISTENING SESSION FEEDBACK EXAMPLES

- IMPROVE FISH HEALTH THROUGH VACCINES, GENETICS, NUTRITION, PRODUCTION SYSTEMS, MICROBIOME
- GENETIC IMPROVEMENT
- FISH MEAL AND OIL REPLACEMENT
- COST EFFECTIVE DIETS THAT IMPROVE PERFORMANCE DECREASE ENVIRONMENTAL IMPACT
- FLESH QUALITY
- STERILITY
- GENE EDITING
- HUMANE SLAUGHTER
- AUTOMATED INVENTORYING AND GRADING SYSTEMS
- TROUT WITH NO PIN BONES

SALMONID STAKEHOLDER INPUT

- "GENOMIC TECHNOLOGIES FOR ASSESSING CONTINENT OF ORIGIN FOR ATLANTIC SALMON" WORKSHOP HOSTED BY USDA ARS AND NIFA AND THE U.S. FISH AND WILDLIFE SERVICE (USFWS) IN ORONO, MAINE, ON JUNE 5, 2018 (~20 PARTICIPANTS).
- A LISTENING SESSION HOSTED BY USDA ARS AND NIFA AT THE NATIONAL COLD WATER MARINE AQUACULTURE CENTER IN ORONO, MAINE, ON JUNE 6, 2018 (~25 PARTICIPANTS).
- THE "CHANGE AND ADAPT: GET MORE OUT OF LESS" MEETING HELD BY THE U.S. TROUT FARMERS ASSOCIATION AT THE USFWS NATIONAL CONSERVATION TRAINING CENTER IN SHEPHERDSTOWN, WEST VIRGINIA, SEPTEMBER 6-8, 2018, ~79 PARTICIPANTS).
- AQUACULTURE2018@ARS.USDA.GOV
- DIRECT AND INFORMAL CONVERSATIONS BETWEEN STAKEHOLDERS AND SCIENTISTS

GENETICS, BREEDING AND BROODSTOCK

- CONTINUE SELECTION IN ATLANTIC SALMON FOR GROWTH IN NET PEN PRODUCTION SYSTEMS WHILE MINIMIZING INBREEDING
- EVALUATE GENETIC BY ENVIRONMENTAL INTERACTIONS FOR ATLANTIC SALMON REARED IN RECIRCULATION AQUACULTURE SYSTEMS AND NET PENS, ESTABLISH A BREEDING PROGRAM TO IMPROVE PERFORMANCE OF ATLANTIC SALMON IN RECIRCULATING AQUACULTURE SYSTEMS
- DEVELOP BROODSTOCK FOR YEAR-ROUND AVAILABILITY OF ATLANTIC SALMON EGGS
- NEED FOR SPECIFIC PATHOGEN FREE FISH, INCLUDING HPR0
- STAKEHOLDERS DOCUMENTED A LACK OF INTEREST IN THE NCWMAC ARCTIC CHAR BROODSTOCK, FAVORING CRYOPRESERVATION OF THE LINE AND SHIFTING OF RESOURCES TO HIGHER PRIORITIES.
- ESTABLISH LUMPFISH BROODSTOCK SELECTED FOR EFFECTIVELY REMOVING SEA LICE.
- SEASONAL AVAILABILITY OF LUMPFISH

NUTRITION

- EVALUATE THE IMPACT OF FISH FEEDS ON OFF FLAVOR IN RAS
- EVALUATE THE IMPACT OF DIFFERENT BINDERS ON FEED DIGESTIBILITY AND WATER QUALITY IN RECIRCULATING AQUACULTURE SYSTEMS
- VALIDATE US SOURCES OF SINGLE CELL PROTEIN, ALGAL OIL AS INGREDIENTS IN FISH FEEDS

.

- USING WASTES FROM LOCAL INDUSTRIES TO DEVELOP FEEDS FOR LOCAL FISH PRODUCTION.

.

- EVALUATE NATURAL AND SYNTHETIC SOURCES OF PIGMENTS.

FISH HEALTH

- INTEGRATED TECHNOLOGIES THAT REDUCE IMPACTS OF SEA LICE
- EXPLORE POTENTIAL FOR DISEASE TRANSMISSION USING LUMPFISH?
- VACCINES FOR LUMPFISH PATHOGENS
- VACCINES FOR ATLANTIC SALMON PATHOGENS
- DEVELOP INTEGRATED APPROACHES FOR MANAGING FISH HEALTH IN RAS, SIMILAR TO NCCCWA APPROACHES FOR RAINBOW TROUT.
- NEED FIELD VALIDATIONS OF DIFFERENT ALTERNATIVES TO ANTIBIOTICS: DO PRE- AND PRO-BIOTICS HAVE PRACTICAL APPLICATIONS FOR FISH HEALTH?

ADDITIONAL PRIORITIES

- WORKFORCE DEVELOPMENT FOR MAINE AQUACULTURE INDUSTRY. NEED FOR TRAINING WITH SKILLS THAT REDUCE THE COST/RISK OF NEW HIRES (INCLUDING HANDS-ON EXPERIENCE)

- TOOLS FOR TRACEABILITY OF SEAFOOD IN THE US MARKET-PLACE.

- EDUCATION (YOUTH, MILLENNIALS) ON CURRENT PRACTICES IN AQUACULTURE (E.G., 4-H, STEM EDUCATION)

- **WASTE DISCHARGE MANAGEMENT IN RECIRCULATING SYSTEMS. WHAT VALUE IS THERE IN THE SOLIDS RECOVERED?**

ACTION PLANS

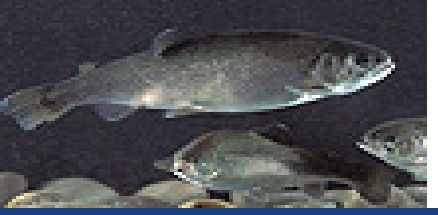
2015

- COMPONENT 1: SELECTIVE BREEDING, DIRECTED REPRODUCTION, AND DEVELOPMENT OF GENOMIC TOOLS
- COMPONENT 2: NUTRIENT REQUIREMENTS AND ALTERNATIVE SOURCES OF PROTEIN AND LIPID
- COMPONENT 3: HEALTH OF AQUATIC ANIMALS
- COMPONENT 4: SUSTAINABLE PRODUCTION SYSTEMS
- COMPONENT 5: PRODUCT QUALITY AND NEW PRODUCTS

2020

- COMPONENT 1: CATFISH
- COMPONENT 2: SALMONIDS
- COMPONENT 3: HYBRID STRIPED BASS
- COMPONENT 4: SHELLFISH
- *COMPONENT 5: MARINE FINFISH*

https://www.ars.usda.gov/animal-production-and-protection/aquaculture/docs/action-plan/



Developing Projects

- ✓ Problem solving
- ✓ Conduct long term research, for existing industries
- ✓ Assemble teams, including multidisciplinary expertise when appropriate and including critical partnerships
- ✓ Research that takes higher risks than industry, but not short term funding
- ✓ Balance basic and applied research
- ✓ 2019 peer review, 2020 implementation, 2023 review

STATUS AND STRATEGIC PLANNING

Aquaculture genomics, genetics and breeding in the United States: current status, challenges, and priorities for future research.

BMC Genomics 2017 18(1):191

US Country Report on Aquatic Genetic Resources

2017 submission to FAO

Marine Fish Aquaculture Scoping Workshop March 2017

Session in Aquaculture 2019.

Genetic Improvement in Aquaculture in the United States: Support, Strategies, Risks and Benefits.

Gruenthal *et al.*

Genome to Phenome: Improving Animal Health, Production and Well-Being:

A new USDA Blueprint for Animal Genome Research 2018 - 2027

National Strategic Plan for Federal Aquaculture Research 2014 – 2019

Interagency Working Group on Aquaculture

“In the past, it has been more common to examine problems in a defined space or discipline for reasons related to practicality and greater ease of management, and that approach has been effective at addressing distinct issues that require specific knowledge in a domain. ***The urgent progress needed today to address the most challenging problems requires leveraging capabilities across the scientific and technological enterprise in a convergent research approach.”***

HTTPS://DOI.ORG/10.17226/25059