Thank you both very much for bring me here after 36 years!

Mr. Itamar Rocha, Organizer of both Symposia

Mr. I.T. Guo, NangRong Group., Shanghai

Merits and Constraints of Artificial Intelligence Application on Pond-based Aquaculture

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Artificial Intelligence, AI: Teaching computers to learn and think like humans.

Computer		Human
Student		Teacher
Teacher		Student
Apprentice		Master
Master		Apprentice
Employee		Employer
Employer		Employee
Staff Officer		Commander
Commander		Staff Officer
…		…
Partners	**Brotherhood**	**Partners**

Statistics and Artificial Intelligence: Algorithmic Comparison

Statistics and Artificial Intelligence (AI) share deep logical and methodological roots, yet they diverge in how they approach modeling, inference, and decision-making. Below is a concise comparison emphasizing algorithmic similarities and differences.

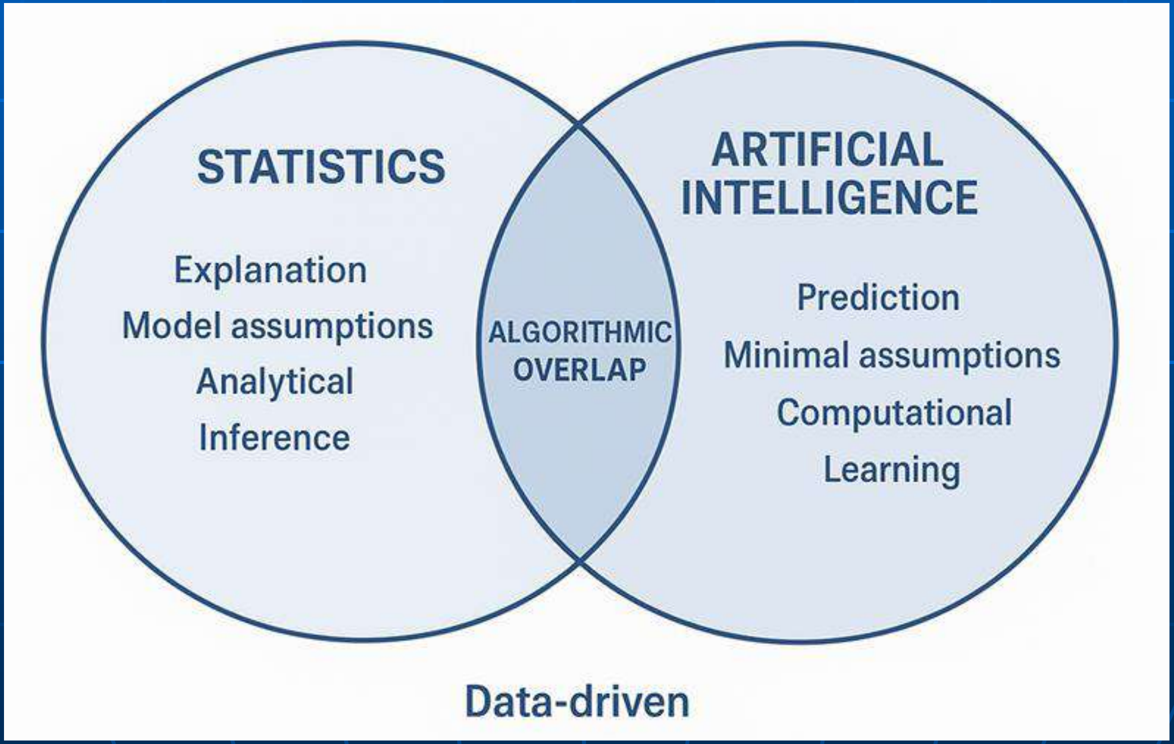
(Source: Chien, Y.-H., & ChatGPT (2025). Algorithmic overlap between statistics and artificial intelligence [Venn diagram]. Created using OpenAI's ChatGPT (GPT-5 model), October 22, 2025)

Core Similarities (Algorithmic Perspective) – Overlap

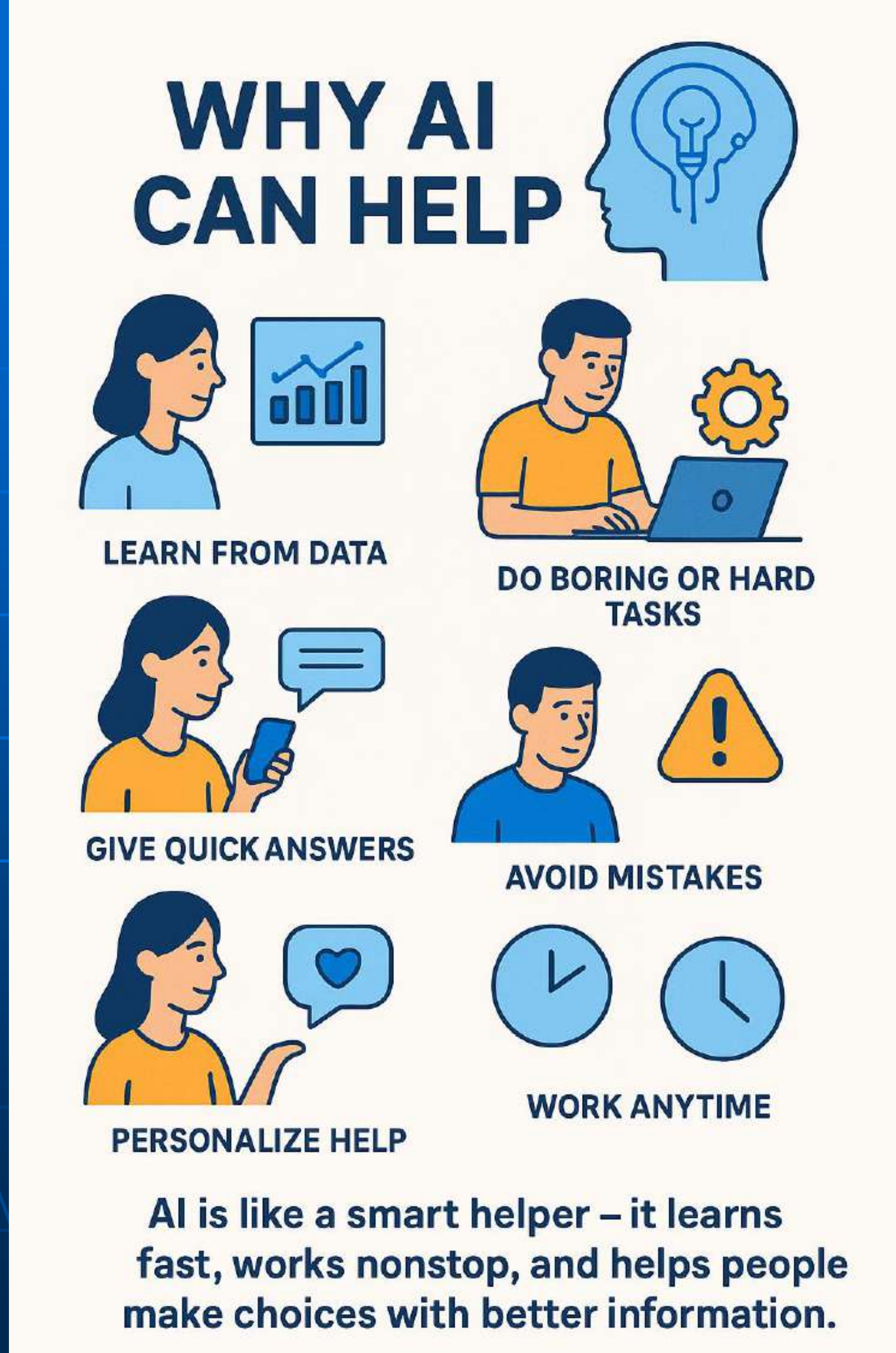
Both fields rely on data-driven reasoning, model formulation, parameter optimization, and validation. They share a logical process: define a problem, gather data, apply an appropriate model, and evaluate outcomes with probabilistic reasoning.

Major Dissimilarities (Algorithmic and Philosophical) – Both ends

Statistics aims for explanation and inference under well-defined assumptions, using interpretable analytical models.

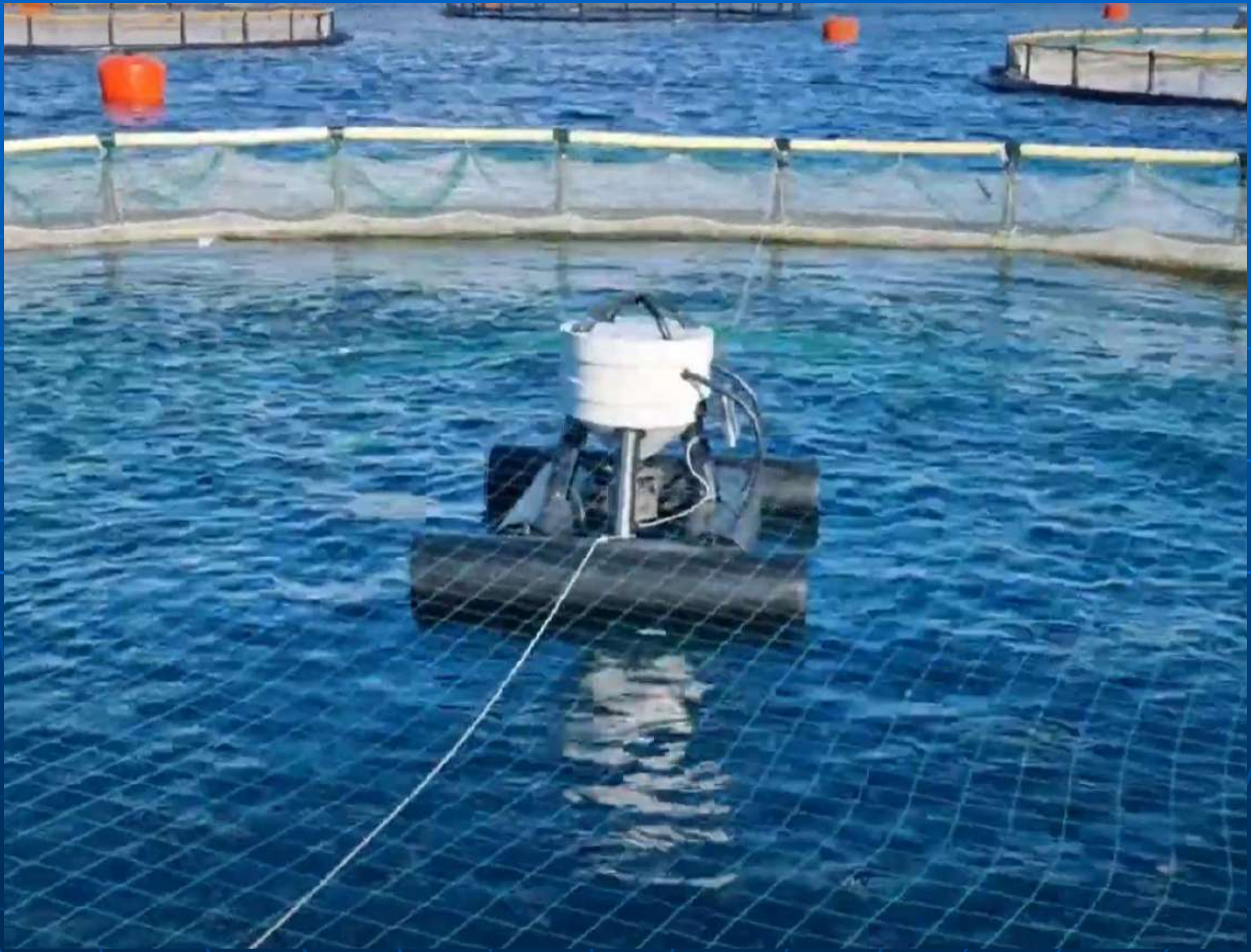


AI emphasizes prediction and adaptability, using computationally intensive algorithms with minimal assumptions.

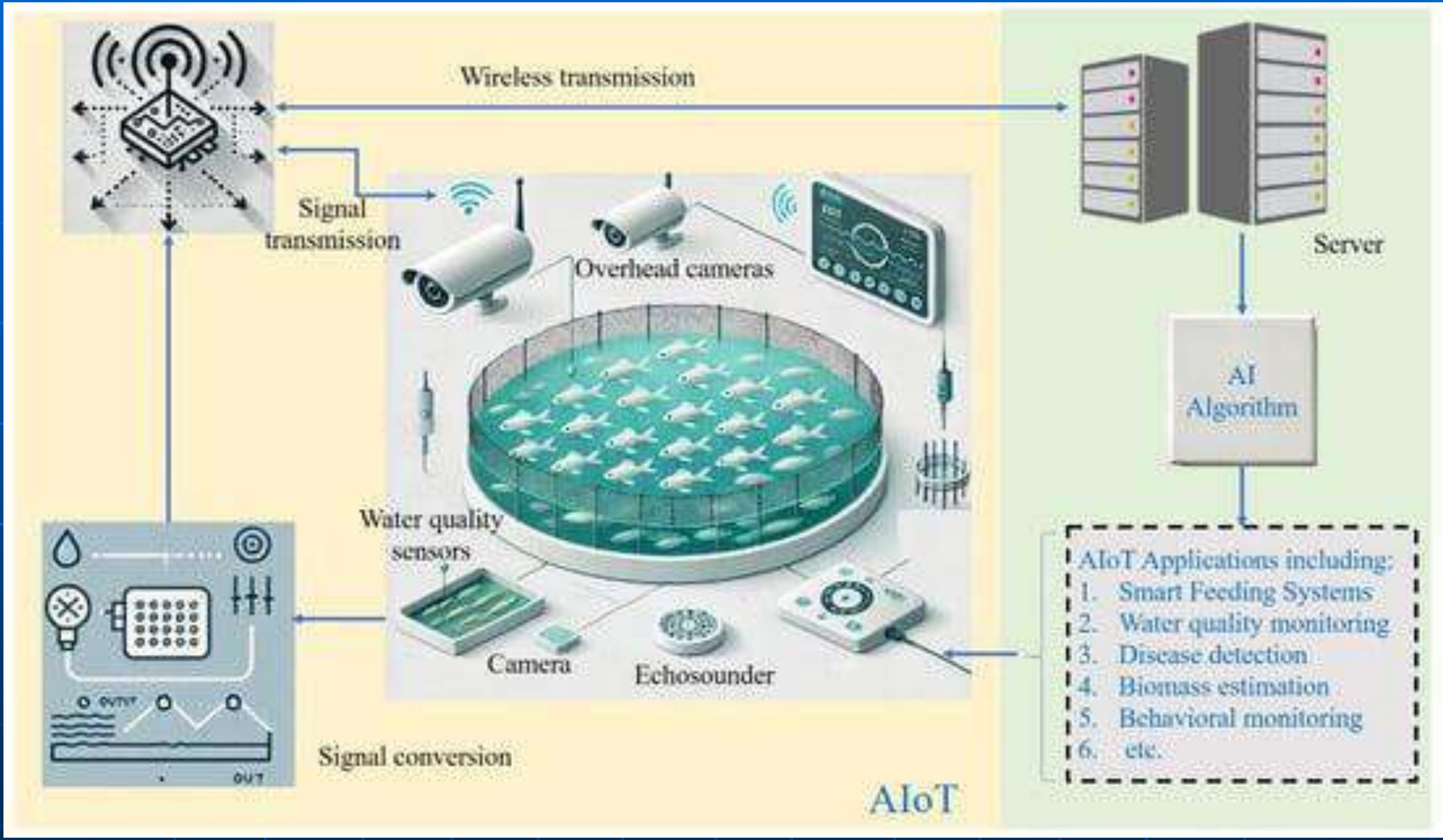

WHY AI CAN HELP
LEARN FROM DATA
DO BORING OR HARD TASKS
GIVE QUICK ANSWERS
AVOID MISTAKES
PERSONALIZE HELP
WORK ANYTIME
AI is like a smart helper – it learns fast, works nonstop, and helps people make choices with better information.

Was then, the cage aquaculture.

What it is now,



and will be? !!!



AIot = AI + IoT (Internet of Things)

OUTLINES(1/2)

I. AI Applications in Aquaculture*

Monitoring & control systems,
Stocking & harvesting management,
Disease detection & prevention,
Feed optimization & feeding management,
Reproduction management,
Conservation genetics, and
Environmental impact assessment and mitigation.

* Sea cage culture first, then focus on pond-based culture.

OUTLINES(2/2)

II. AI Adoption Challenges

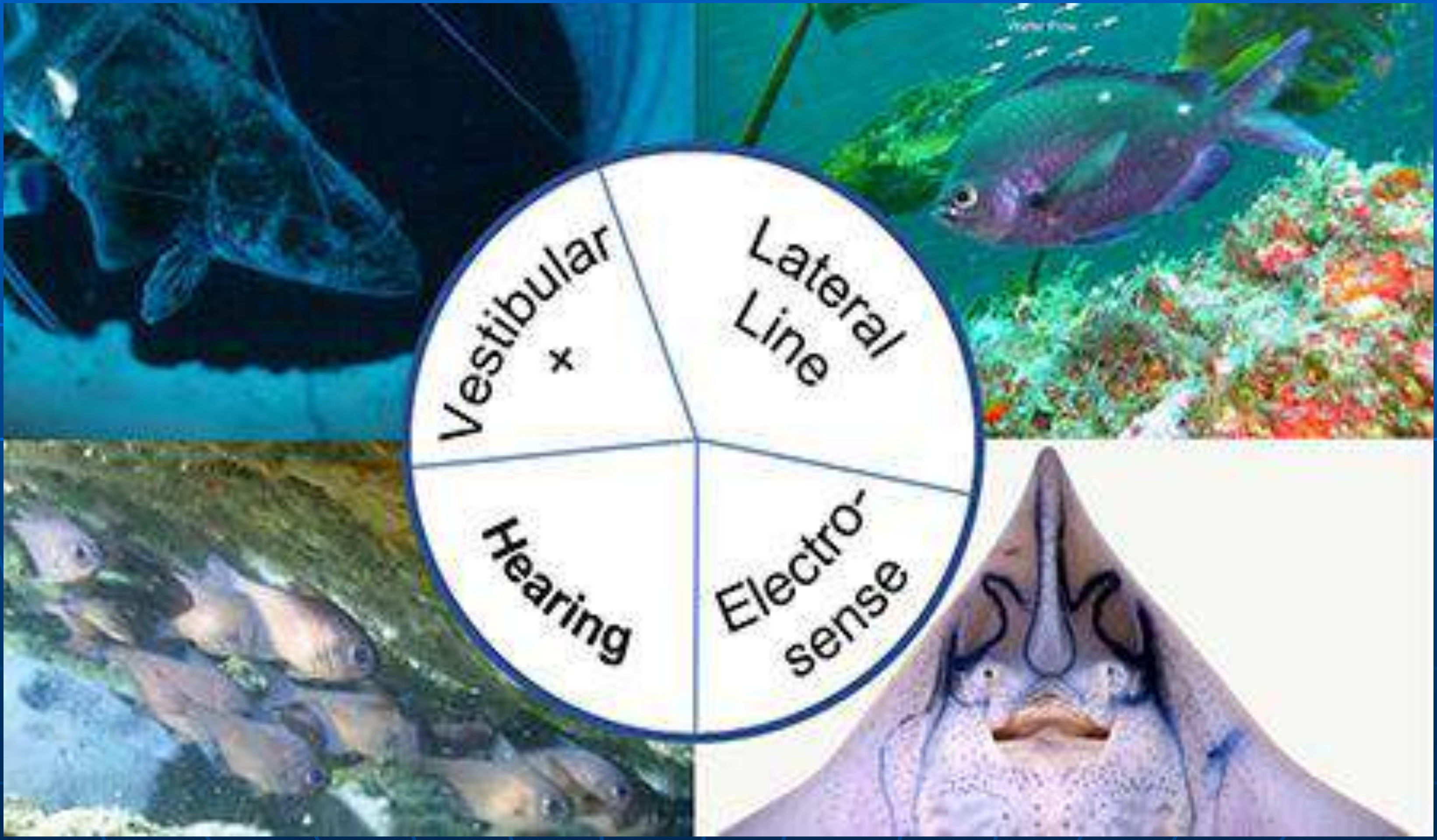
Acquisition cost,
Lack of technical know-how,
Reliability/Effectiveness of the AI solution.

III. Solutions for Challenges

Incorporate a data centric approach to AI,
Establish an open fishery database,
Adopt standardized data formats,
Set protocols for sharing data,
Build highly reliable and low cost sensors,
Maintenance support by AI solution providers, and
Mobile app embedded AI.

To Know Aquatic Animals' Feeling

Where in their body and how the fish perceive the change in the exterior environment?



HOW TO MAKE DETECTIONS on their activity? Video & Audio

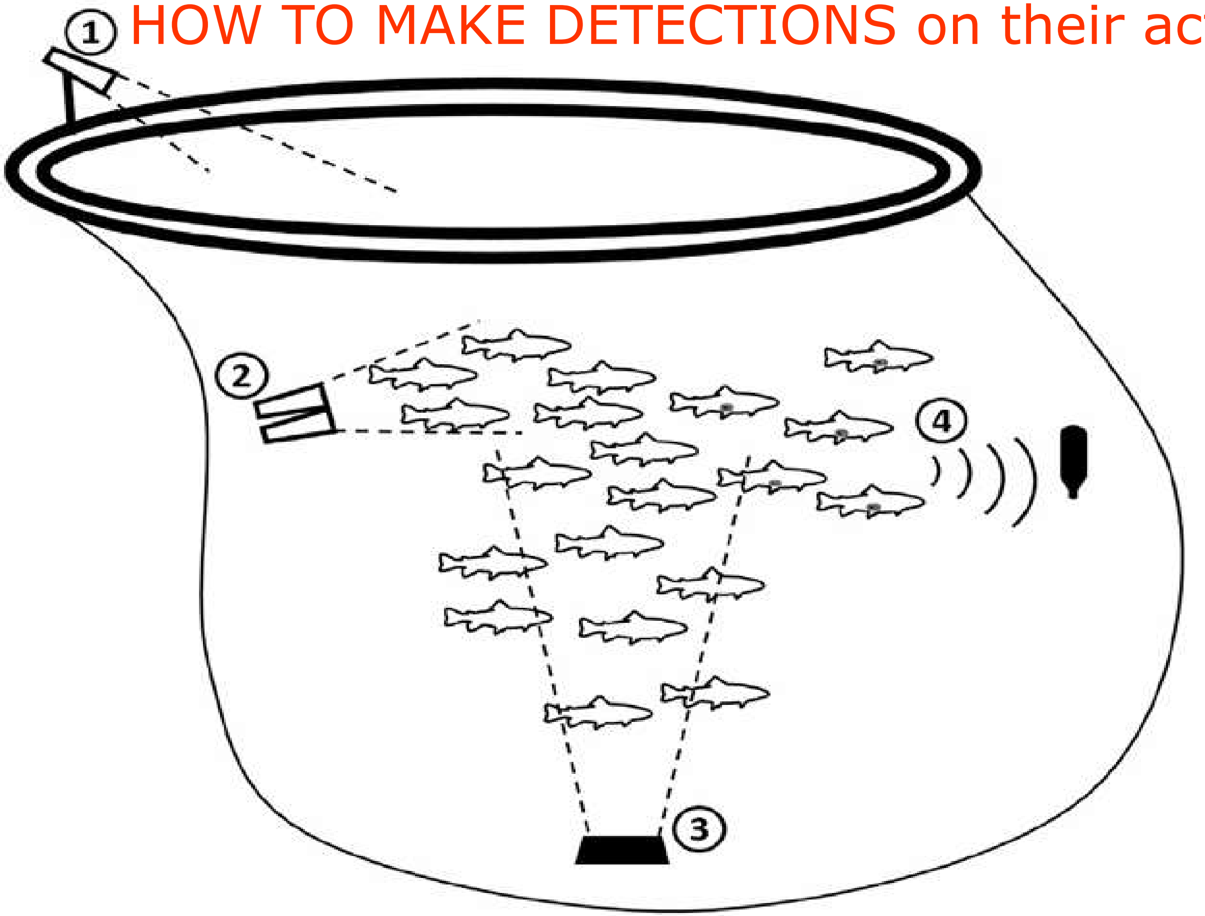
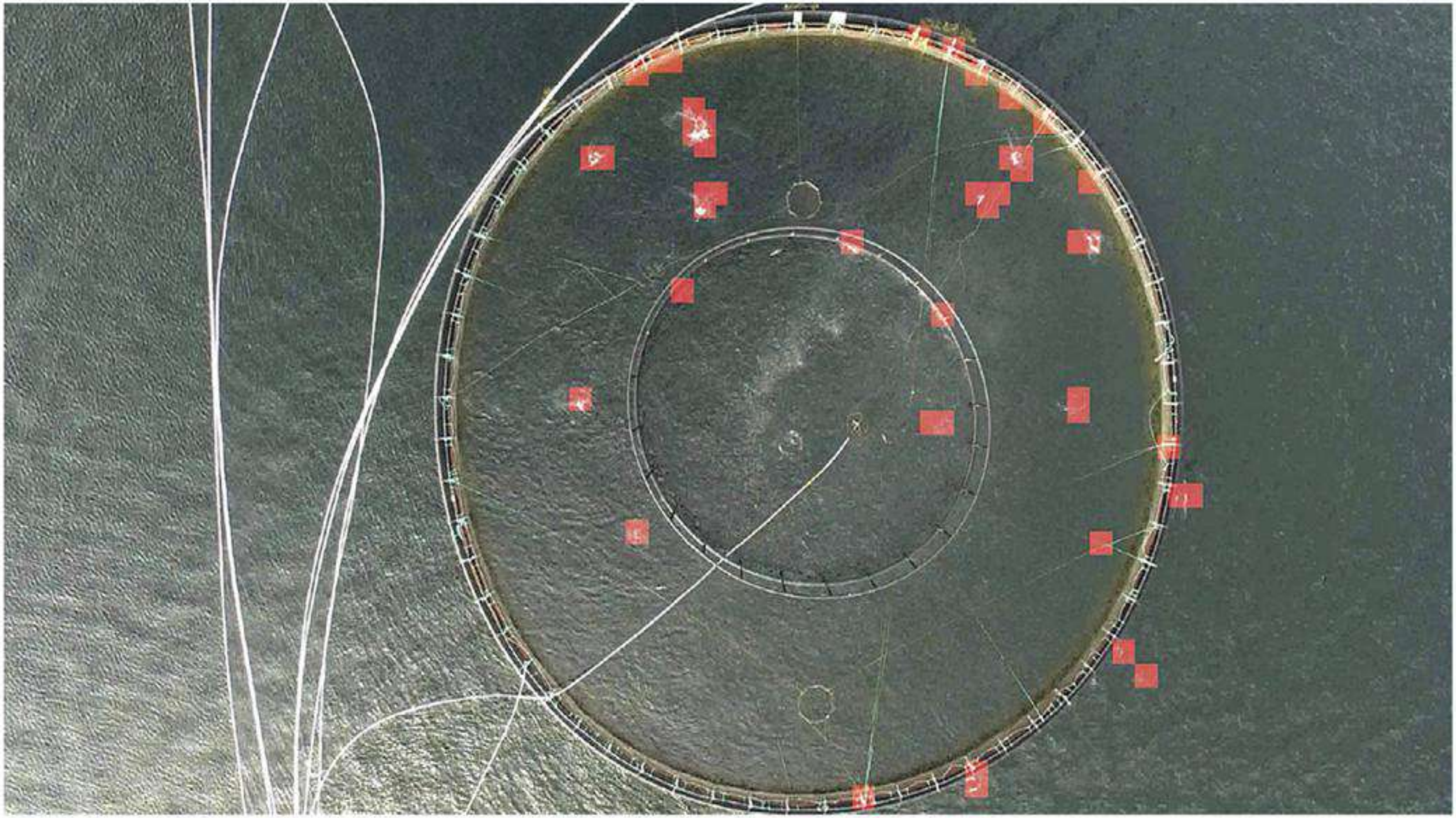


Illustration of how four systems based on different monitoring principles could be deployed in a commercial cage to observe the fish. While the surface camera (1), underwater stereo video camera (2) and sonar system(3) produce data on the fish within a sub-volume in the cage(delimited by dashed lines for each system),the acoustic telemetry system(4) may collect data on the individual fish carrying acoustic transmitters irrespective of their location in the cage. Føre et al. (2018)

& Aerial



Example of automatic detection of surface activity in salmon cages using computer vision methods. Each red square marks the detection of a splash be caused by fish. [Reproduced from Jovanovic et al. (2016) with permission of copyright holder. Martin Føre et al. (2018)]

Marsupenaeus japonicus

Penaeus monodon

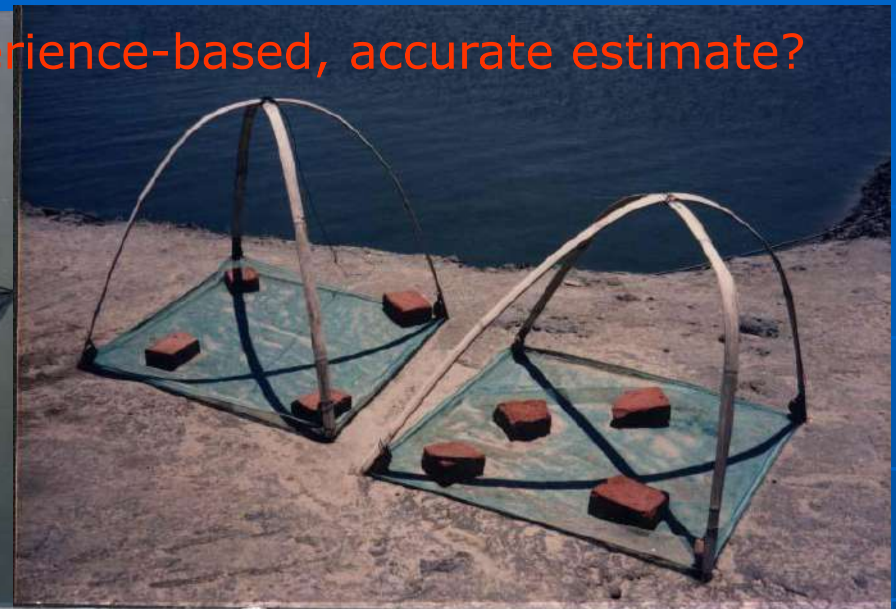
Penaeus penicillatus

Litopenaeus vannamei


Dawn-Semi-bury
A
B
Dusk- Head-out
Kuruma prawn Marsupenaeus japonicus, the most expensive penaeids, their best feeding time is from dusk(B), through the night(C), until dawn(A).
Night-Exposed
C
D
Daytime-Bury

Primitive and simple, but most direct and efficient way to find out shrimp feeding results

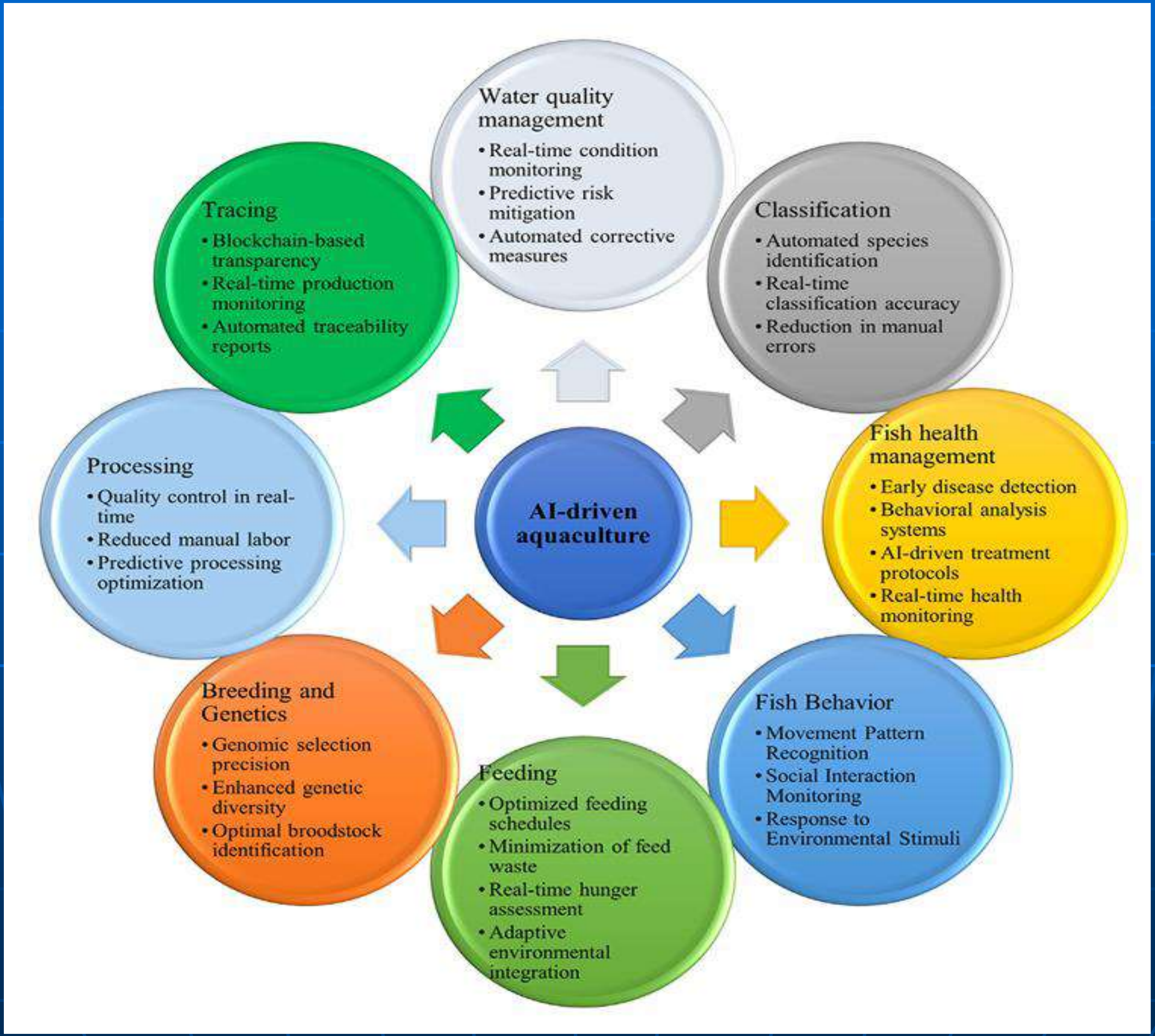
Labor intensive and experience-based, accurate estimate?



Good feed and feeding management

1. Rather compound feed than trash fish;
2. Rather grain meal and animal waste meal than fishmeal.
3. Good stability, palatability, FCR.
4. High frequency and low quantity,
   good timing and location,
   rather under than over feeding, and
   close observation.

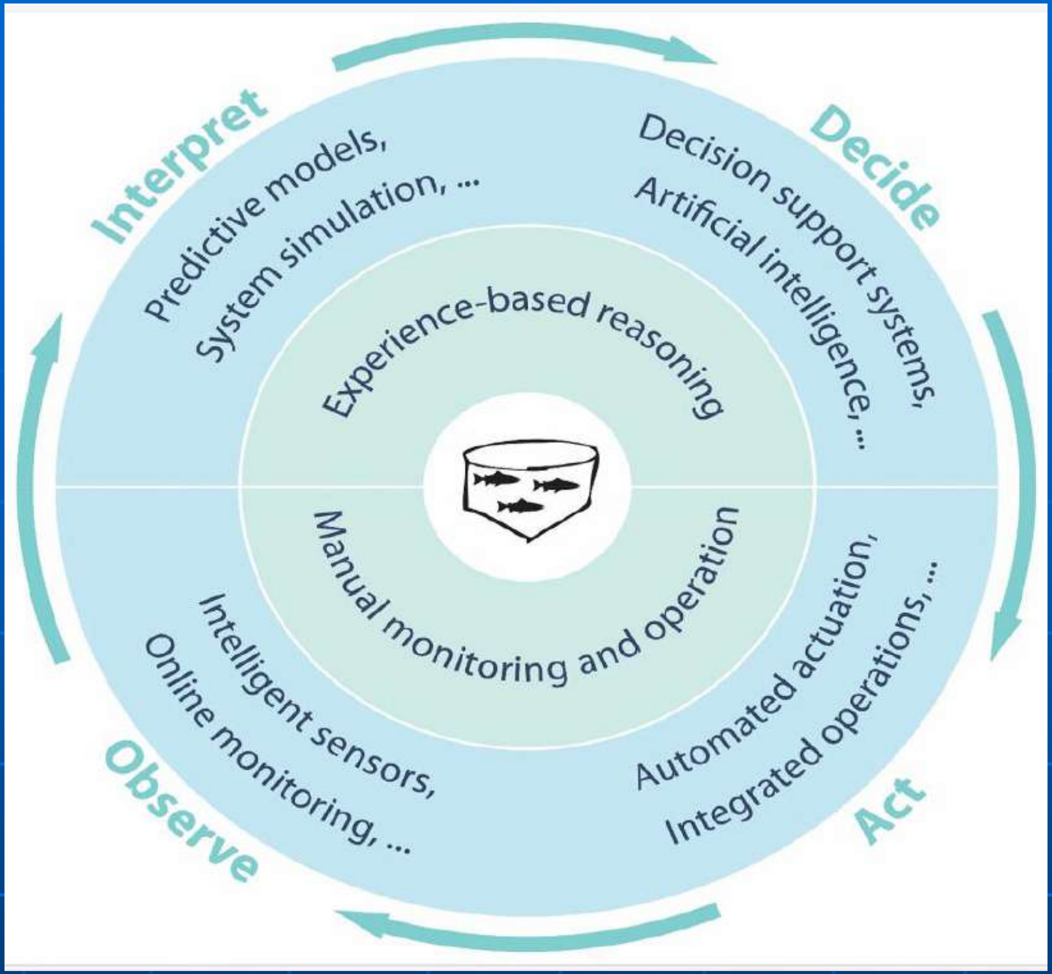
Overview of AI applications in aquaculture



Yang et al. 2025. https://doi.org/10.1016/j.aiia.2025.01.012

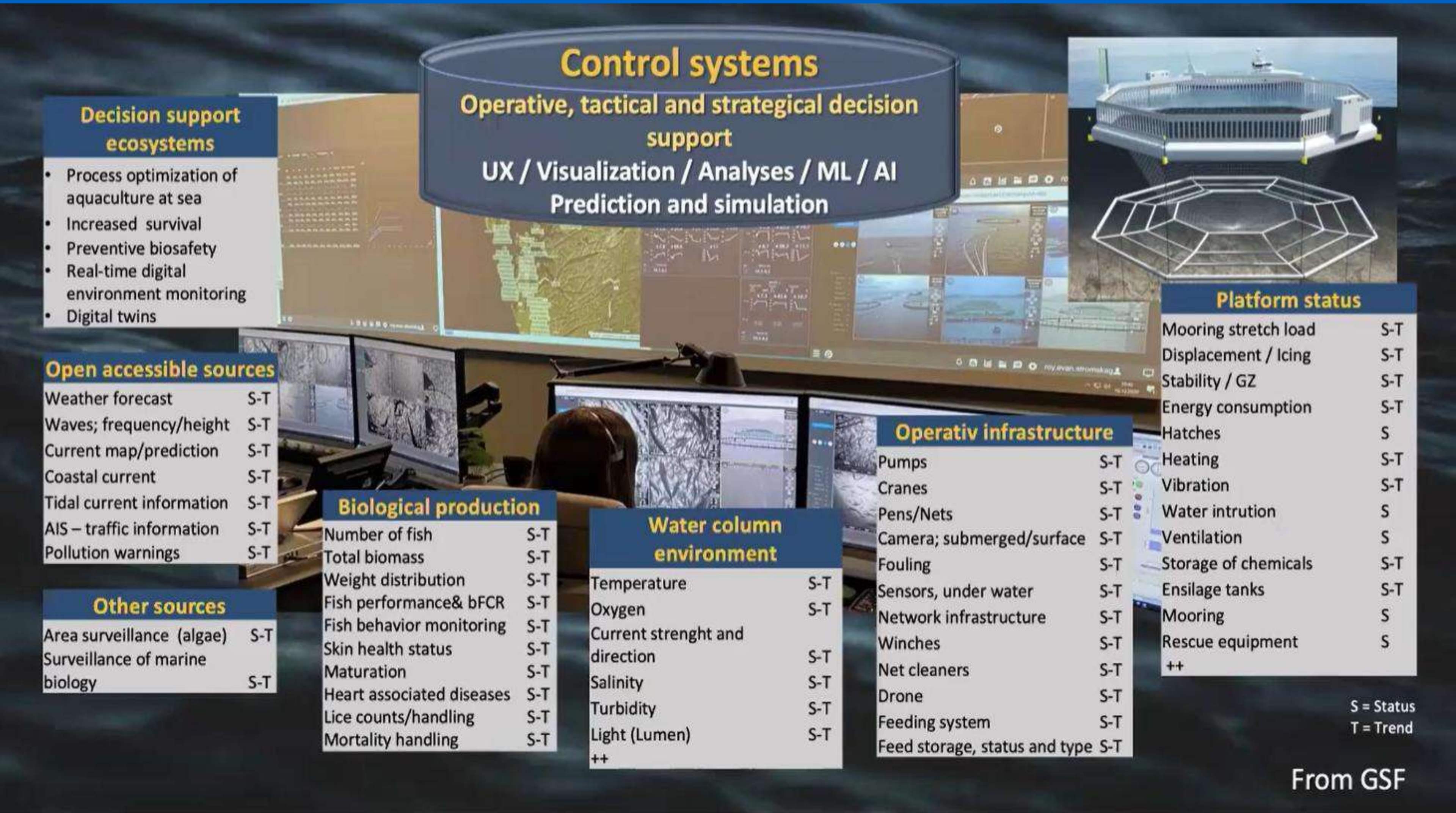
Applications of AI in aquaculture

- Real-time information of environment and fish behavior
- Automated biomass measurements
- Feeding optimization and automation to lower FCR and feed spill
- Early warning of disease and parasites and their spreading
- Climate change and harmful algae bloom predictions/warning
- Infrastructure and equipment operations & condition monitoring
- Energy use optimization
- Predator warning and parasite removal
- SOP improvements from site to regional production management
- Logistic efficiency
- Product traceability from farm to fork



A cyclical representation of PFF(Precision Fish Farming) where operational processes are considered to consist of four phases: Observe, Interpret, Decide and Act. The inner cycle represents the present state-of-the-art in industry, with manual actions and monitoring, and experience-based interpretation and decision-making. The outer cycle illustrates how the introduction of PFF may influence the different phases of the cycle. Figure credits: Andreas Myskja Lien, SINTEF Ocean. (https://doi.org/10.1016/j.biosystemseng.2017.10.014)

Future control systems, surveillance and operation of remote semi-autonomous aquaculture farming



Aquabyte

Automatic lice counting

Machine vision and lasers kill sealice on salmon in pens like Star Wars

https-//youtu.be/HBAXFN0yQVI

https://www.youtube.com/watch?v=bZxw-Ji7K94

Hydroacoustics

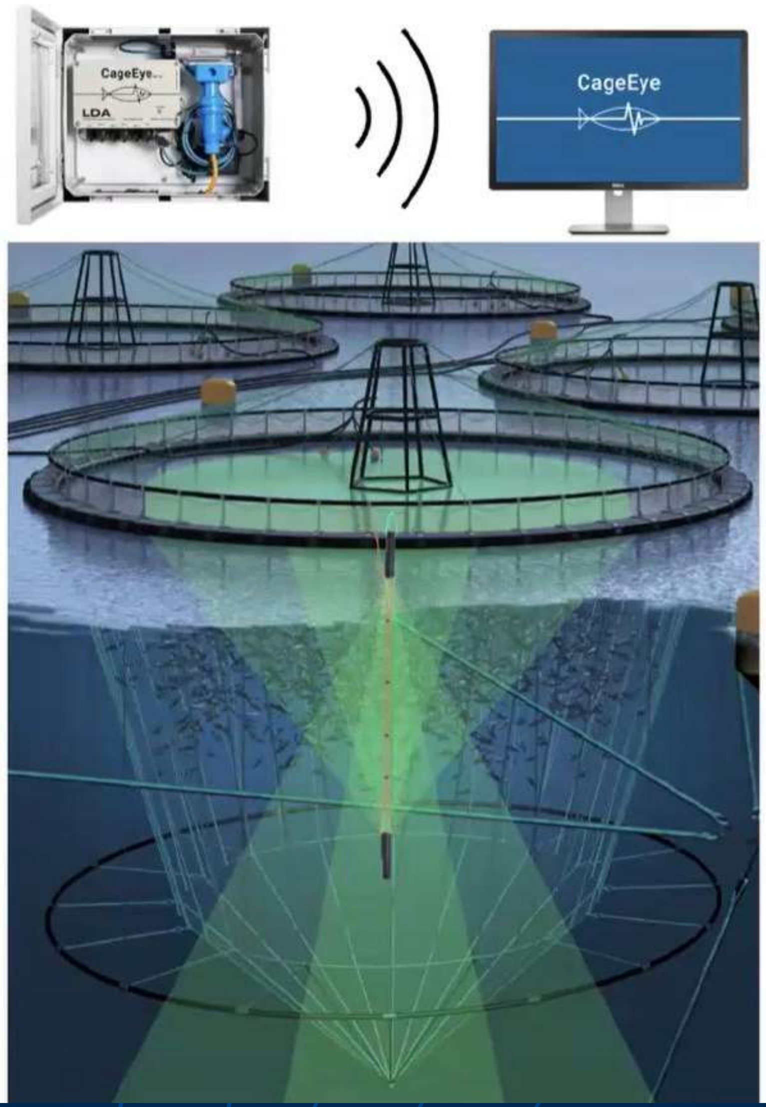
Sound waves echoing off swim bladder;

Cover large volumes

Measuring every second

Independent of light, water quality

Little maintenance



Crowding Companion

Precise monitoring at your fingertips.

- Real time representative data from the fish
- Multiple depth monitoring
- Light signal follow your welfare

Subsurface Monitoring

Understand fish behaviour beneath the surface during crowding operations, with intuitive software connecting your whole team.

Innovative Intelligence

Real time data to all those connected, with Sensor Globe's Smart System, alerting visually through our light system.

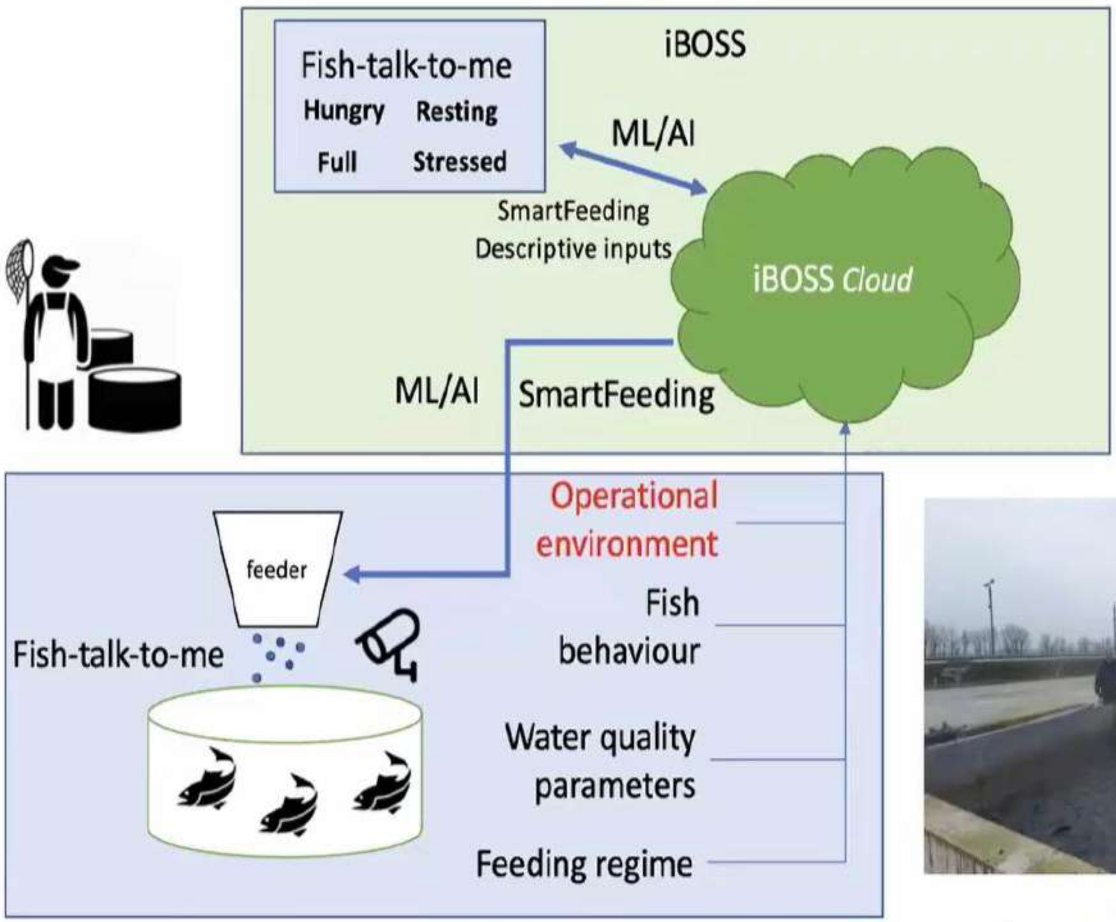
Multiple Depths and Representative

Monitor 3 depths and move with the biomass during crowding, identifying issues before they become problems with representative data from the midst of the crowd.

Sensor Globe


AKVA GROUP
AKVA connect
AKVA observe
AKVA connect
Management system for fish farming
AKVA fishtalk
Production control and planning system
AKVA ecosystem
The glue between digital solutions
AKVA observe
Artificial intelligence in feeding

Fish-talk-to-me and iBOSS



Scaling of understanding and applications

NORCE

Digitizing Production Sites

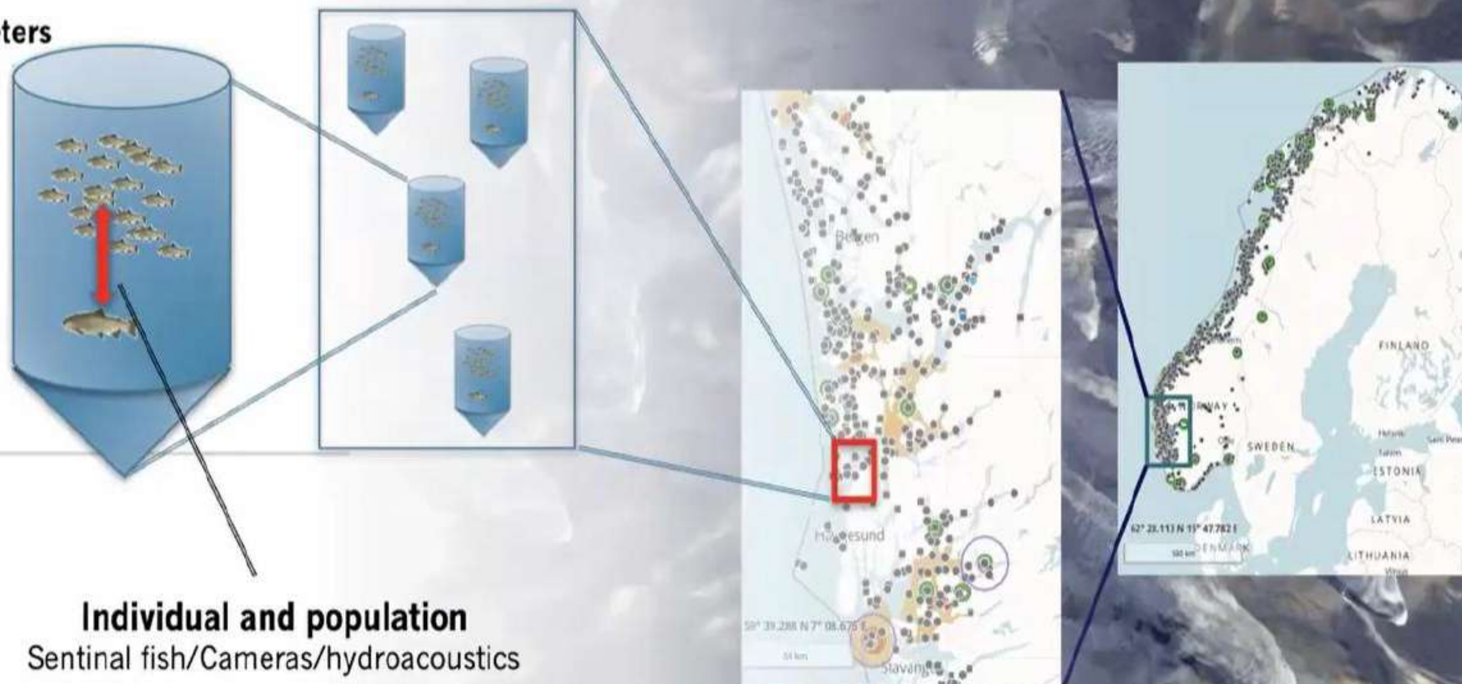
Environmental Parameters
- Density
- Temperature
- Light
- Water speed
- Water quality
- Salinity
- Noise
- Organisms

Biological Parameters
- Growth, FCR
- Feeding,
- Stress
- maturation
- Welfare
- Physiology

Site-to-Site Interaction

Regional

National



Individual and population
Sentinal fish/Cameras/hydroacoustics

1. About 72% of global aquaculture production relies on supplemental feeding. The fraction increases with culture intensification.

2. Feed shares >50% of production cost for intensive culture.

3. Both over- and under-feeding are not favorable for fish’s welfare. Where the optimal or even precision feeding stands?




-- Good Pond-based Aquaculture Practice --

V 1. Feed and feeding management.

2. Water management.

3. Health management.

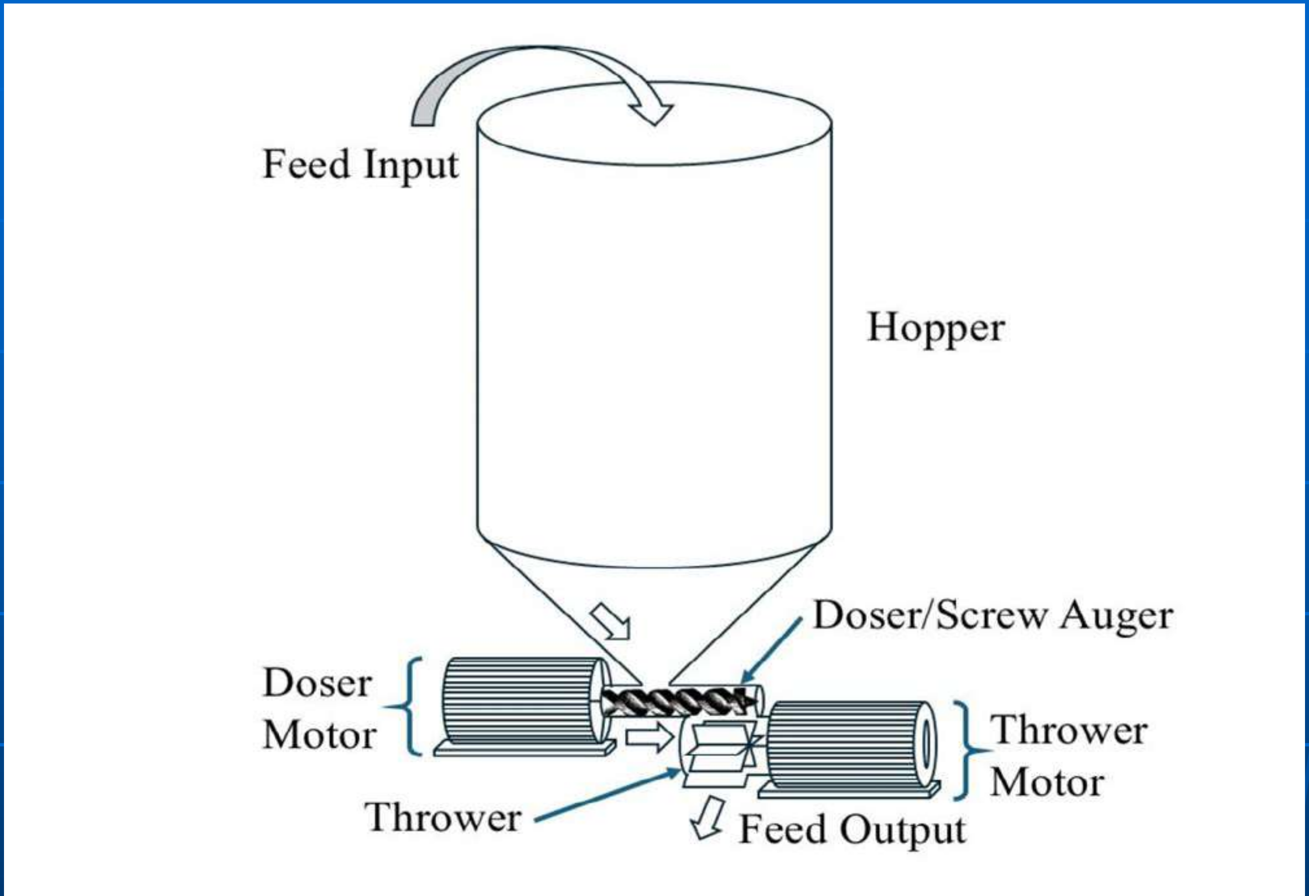
4. Record management and reporting.

3 Basic Feeder Models

Pendulum demand feeder (Fish Farm Supply Co., 2025)

Auger-only automatic feeder (GroAqua, 2025)

Spread/throw automatic feeder (FIAP GmbH, 2025)

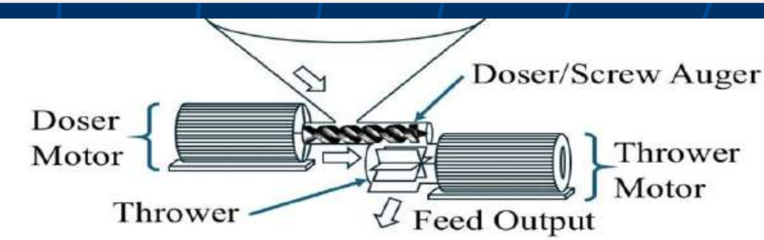


Typical components of single-type automatic fish feeder. White arrows indicate where feed goes in, passes through, and finally is expelled into the water.

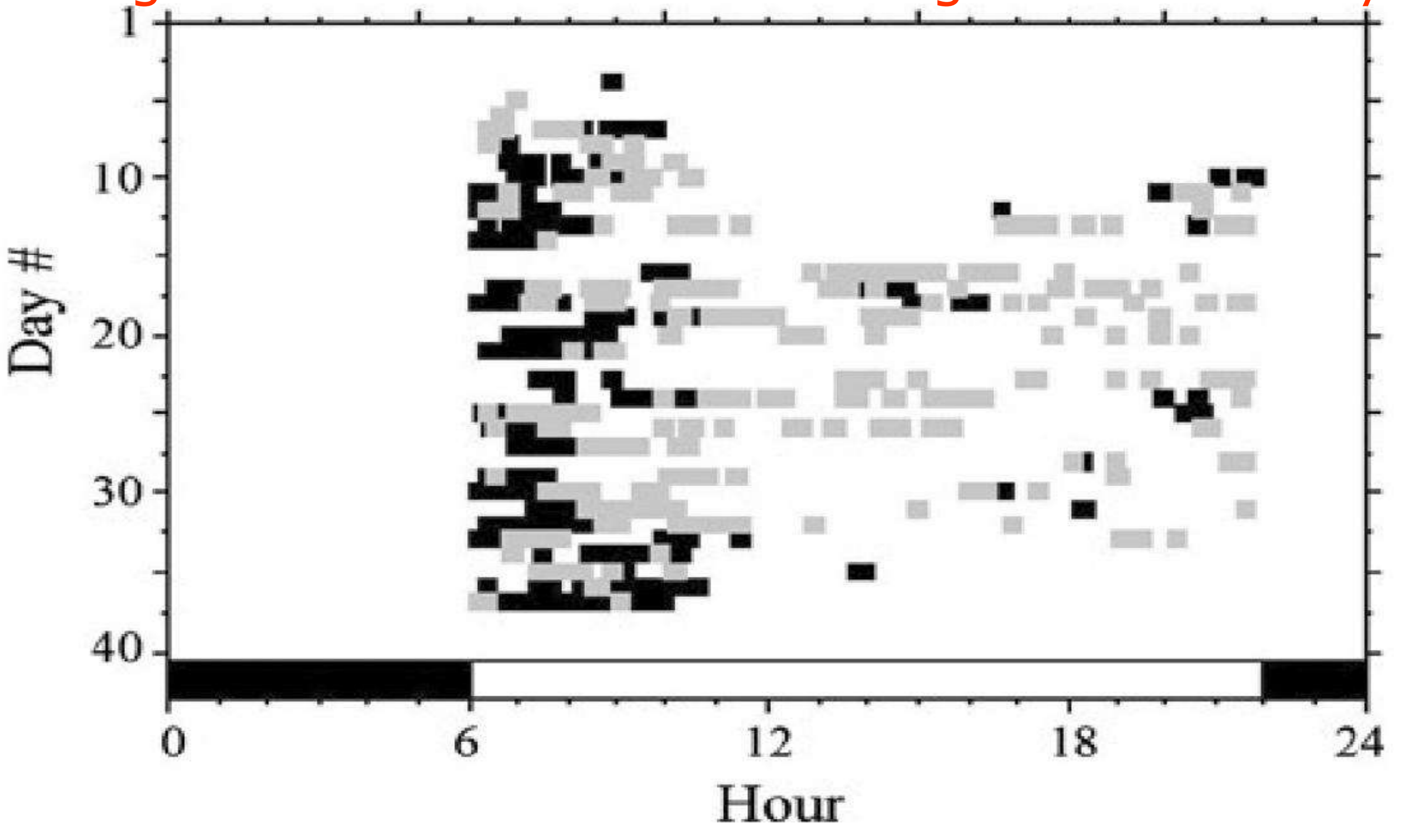
Comparison of 3 basic feed models (Thornburg, 2025)

Pendulum demand feeder | Auger-only automatic feeder | Spread/throw automatic feeder

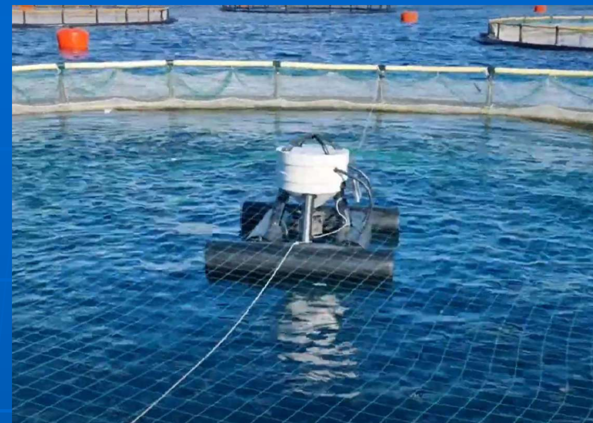
	Pendulum demand feeder	Auger-only automatic feeder	Spread/throw automatic feeder
Electricity required	No	Yes (low energy)	Yes (higher energy)
Number of motors	0	1	1–2
Dispersal method	Gravity-fed	Gravity-fed from end of auger	Flung by thrower/spreader
Thickness of Feed	Wide Range	1–10 mm	4–20 mm
Example suppliers	Fish Farm Supply Co.	FIAP	FIAP
	Air Water Fish	Fresh by Design	FFAZ
Fish species groups	Carp, trout, catfish, sea bass	Trout, tilapia	Tilapia, carp, eel, sea bass, shrimp
Benefits for Farm	Lower feed waste competition and stress for some species	Feed amount tightly controlled and schedule can be optimized	Feed schedule can be optimized and amount controlled, wide dispersal
Journal references	(Attia et al., 2012; Tajudeen et al., 2018)	(Khater et al., 2021; Gerber et al., 2024)	(Rahayani et al., 2018; Emmanuel et al., 2013)



Triggering demand-feeder –
A good tool for basic fish feeding behavior study



Demand feeder triggering incidents by day and hour for 2 highest-triggering European sea bass in a population of 50. Black bars indicate the 1st high-triggering fish, and gray bars mark the 2nd high-triggering fish (Attia et al., 2012)






調查報告
這裡是福壽飼料的養殖魚塭


(https://www.facebook.com/reel/1340421360953585)
Comment: When in feeding, the fish never surface to take the pellet.
Quiz: In muddy water, how the fish perceive the dropping and moving of the pellet? Not by eye detection but by lateral lines? Or else? Would turbidity be a critical parameter in AI feeding model?

(https://www.facebook.com/watch/?v=1107673587469196)
Comment: Fish swim up to the very surface of the water for feeding.
Quiz: The feeding behavior of this particular fish species? Or, the feeding area is close to the bank and shallow depth forces the fish move to water surface. Would crowding a stress and bad for fish welfare?

https://www.facebook.com/watch/?v=1113581837096366&rdid=wAKqKkoqkUv2mQ1W

Comment: Assuming fish and bird having same speed to catch the feed, there will be 4 events happening when feed pellet reach water surface: (1) fish alone gets the feed, (2) bird alone does, (3) both fish and bird do, and (4) none of fish and bird do (pellet keeps sinking and lost). Therefore, the probability that fish alone gets the pellet is 25%. That is why each scoop of fish feed must be thrown towards the target area at the exact right timing, otherwise, up to 75% of the feed could be down the drain!

Quiz: Can those factors be implemented in AI strategies for PRECISION FEEDING?

https://www.facebook.com/reel/1799056821495287

Comment:

The fish may get more feed pellet from the other fishes' body surface than from the water?

Quiz:

Would spread out the feeding in area (2 opposite corners) and in time (frequency) by simple and low-cost programmed (pre-set) auto-feeder improve manpower efficiency, feeding efficiency and fish welfare.

https://www.facebook.com/reel/1127133062291364

The experienced feeding worker may say:
One dump to the right, one to the left; simple and straight forward, why bother A--ai--.

Comment: Fish overfed and underfed may happen at the same time since the fish may not get their fair share and result in uneven harvestable sizes.

Quiz: Why this farm holds on this feeding strategy and not considering for AI PROCESION FEEDING? There got to have practical reasons. What are they?

Can ‘Optimal feeding’ regime be designed? It should be related to fish’s satiation when fish fed, right?

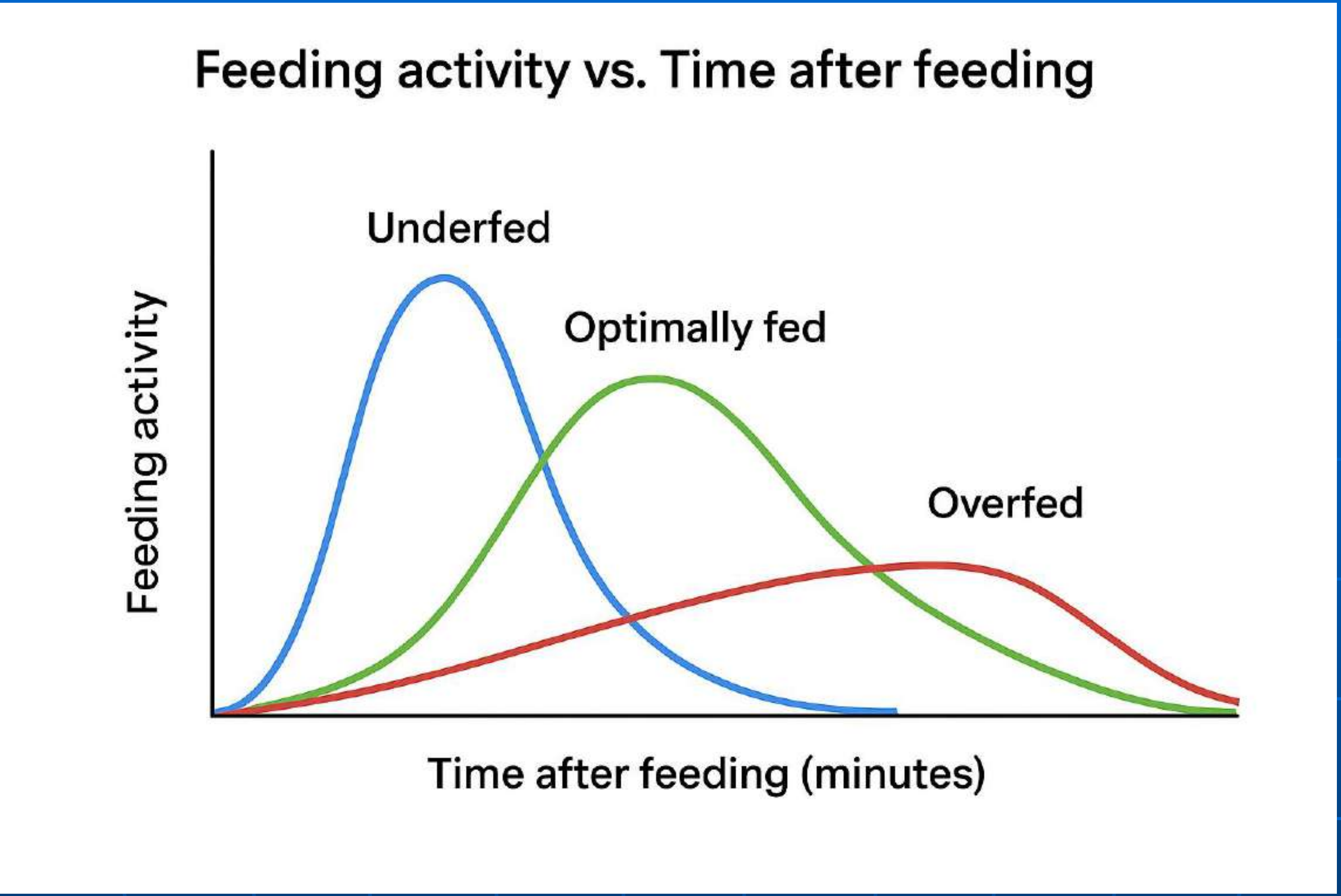
The time from the start of feeding to voluntary cessation was defined as the "satiation time” (Brett, 1971).
Feed conversion of fish fed to satiation was higher than that of fish under restricted feeding (Li, Lovell, 1992).
Across all prey densities, the feeding rates of fish reached a plateau after satiation (Asaeda et al. 2001).
When fish were fed to 80% satiation, FCR, PER, GPE and ECR were markedly better (Bonaldo et al., 2010).
… Fish feeding is one of the enormous tasks that fish farmers are faced with, if the … has showed that feeding the fish to satiation produced better yield compared to a restricted feeding rate (Eriegha, Ekokotu, 2017)

Comment

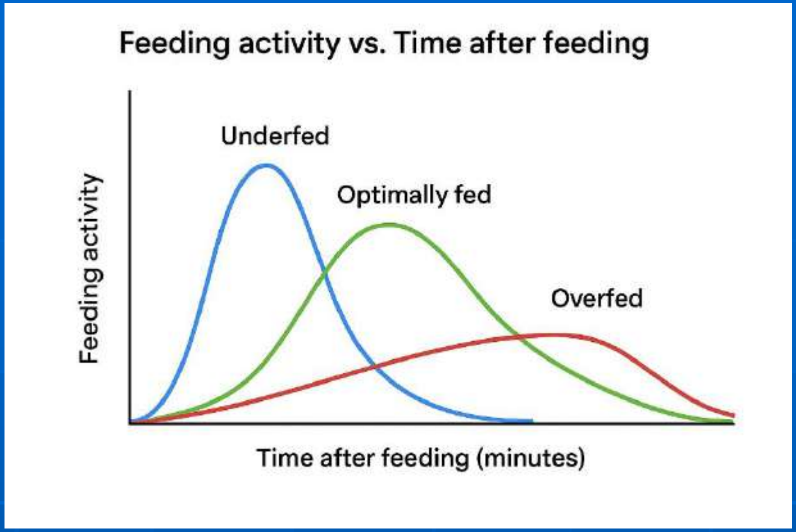
Fish is ‘fed to satiation’ is usually employed in feed and nutrition research experiment as a guideline for ‘optimal and standardized feeding level’. Consequently, underfed and overfed are regarded as the feeding below and beyond that level, respectively.

Q: Supposedly, optimal feeding is the best for fish welfare. How to conduct it in the field?

A: Depending on how to get accurate observations, accumulate experience, make decision and take action.

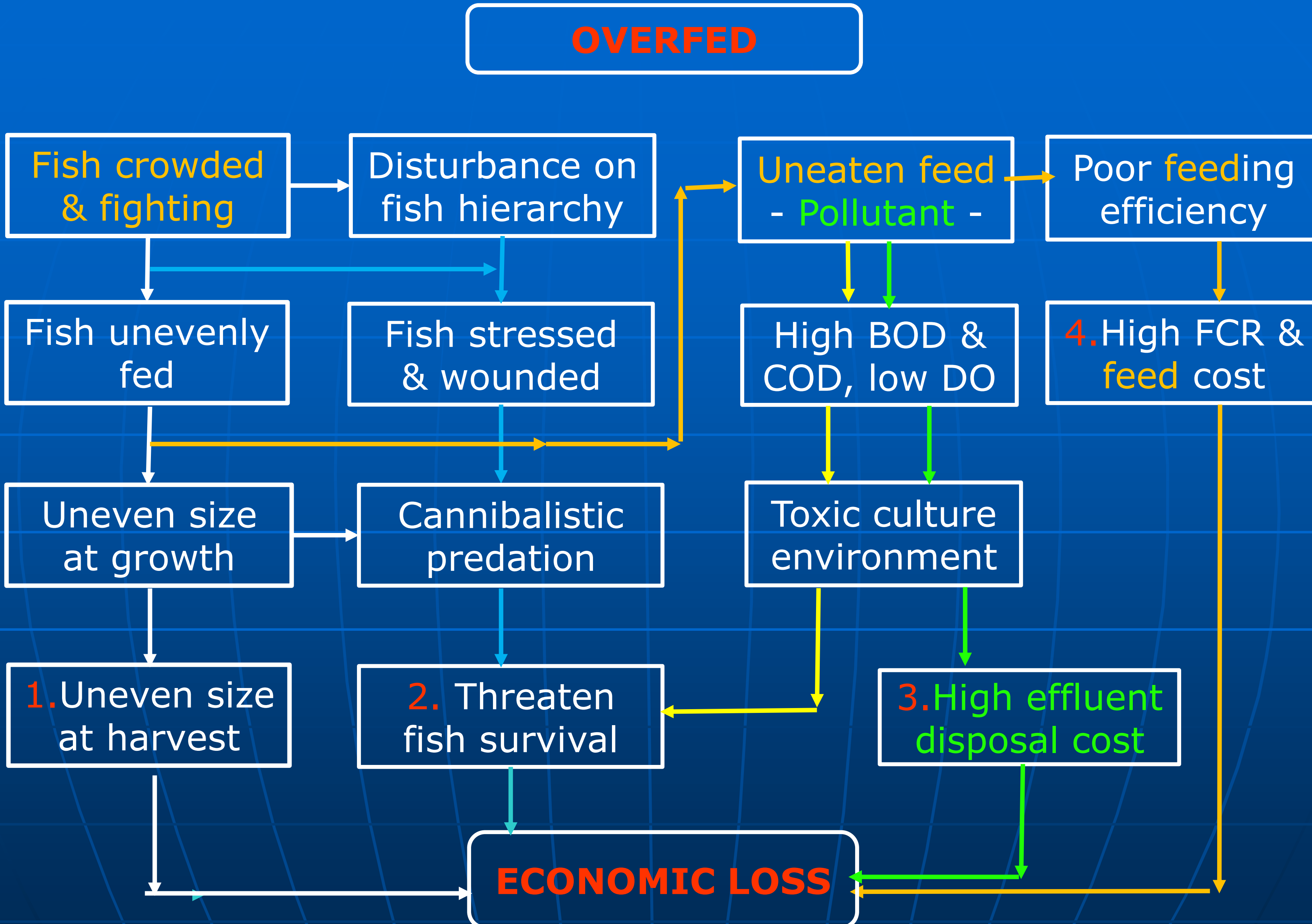


•X-axis: Time after feed given (minutes)
•Y-axis: Feeding activity (e.g., fish surface movement or response intensity)
Underfed — tall, narrow peak, Optimally fed — medium peak with smooth decline, Overfed — lower, wide, prolonged curve
•Interpretation zone: "Feeding should stop around the decline point of the optimal curve."

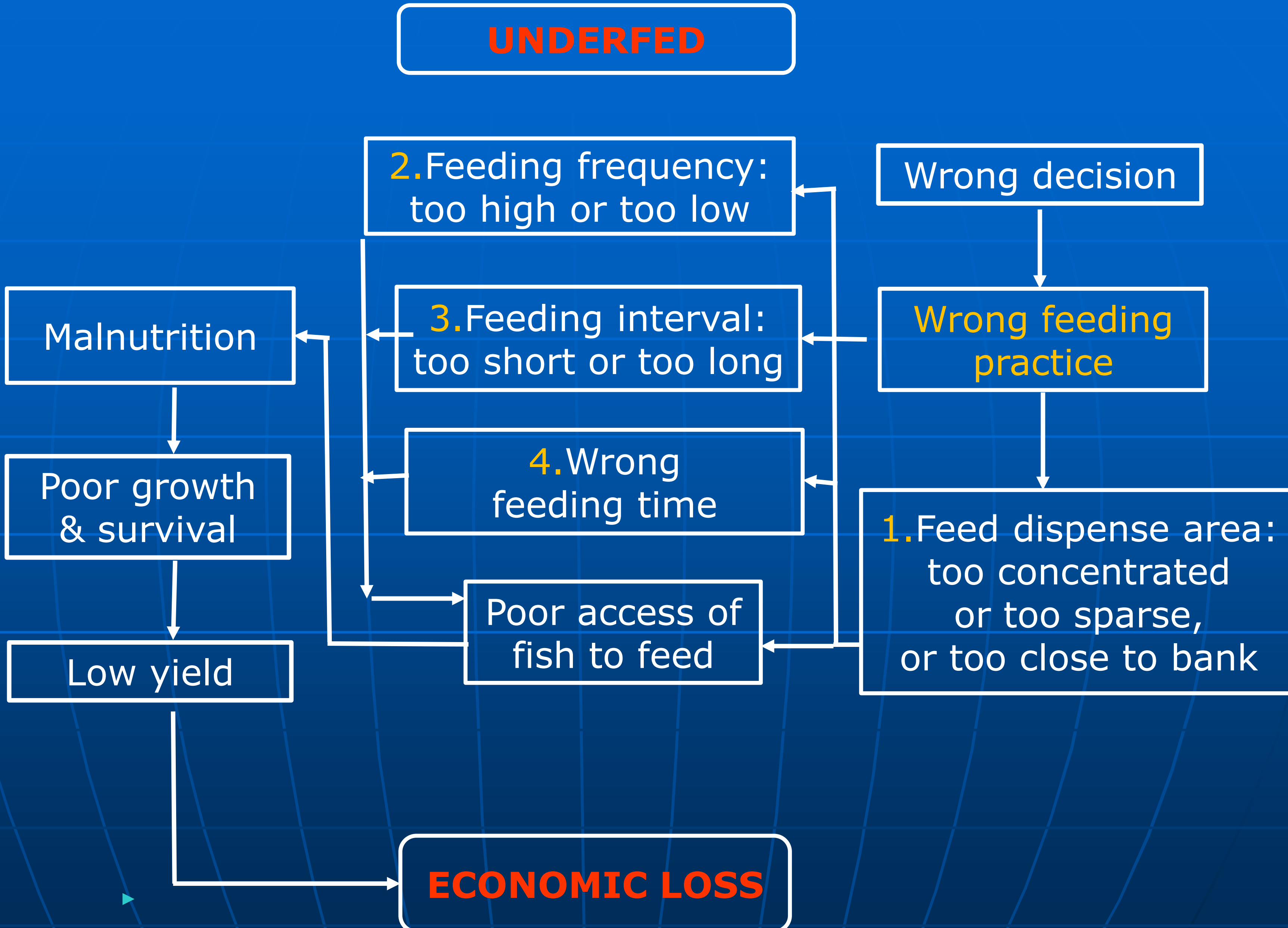


•Interpretation zone:
- "Feeding should stop around the decline point of the optimal curve."

Feeding Condition	Shape of Activity Curve	Practical Meaning
Underfed	Rapid rise to high activity → remains high → ends abruptly when feed is gone.	Fish still hungry after feed is finished; feed insufficient.
Optimally Fed	Sharp rise to strong peak → gradual decline → activity ceases smoothly.	Fish satisfied; feed consumed efficiently.
Overfed	Slower rise → early plateau → low, prolonged tail (feed remains uneaten).	Fish lose interest; leftover feed visible; wasted feed.



OVERFED
Fish crowded & fighting
Disturbance on fish hierarchy
Uneaten feed - Pollutant -
Poor feeding efficiency
Fish unevenly fed
Fish stressed & wounded
High BOD & COD, low DO
4.High FCR & feed cost
Uneven size at growth
Cannibalistic predation
Toxic culture environment
1.Uneven size at harvest
2. Threaten fish survival
3.High effluent disposal cost
ECONOMIC LOSS


UNDERFED
2.Feeding frequency: too high or too low
Wrong decision
3.Feeding interval: too short or too long
Wrong feeding practice
Malnutrition
4.Wrong feeding time
Poor growth & survival
1.Feed dispense area: too concentrated or too sparse, or too close to bank
Poor access of fish to feed
Low yield
ECONOMIC LOSS

Factors Affecting Feeding Behavior of Fish

1. Intrinsic - species (5W3H approach)

1.1. Nature of food habit*: carnivore (grouper), herbivore(grass carp), omnivore(tilapia), etc. (*digestive tract length)

1.2. Availability of food and prey organisms in habitat: detritus feeder, plankton feeder, etc.

1.3. Feeding mechanism: nibble, swallow, wolf (speed and amount)

1.4. Unknown preferences*: feeding layer in water, grouping feeding, circadian instinct, etc.

2. Extrinsic - Environment

2.1. Atmospheric: light, atmospheric pressure, weather, etc.

2.2. Aquatic physiochemical and biological environment: temperature, flow, DO, chemistry, salinity, etc.

2.3. Combined conditions of 2.1 and 2.2, and time; diurnal, seasonal

3. Artificial - Human

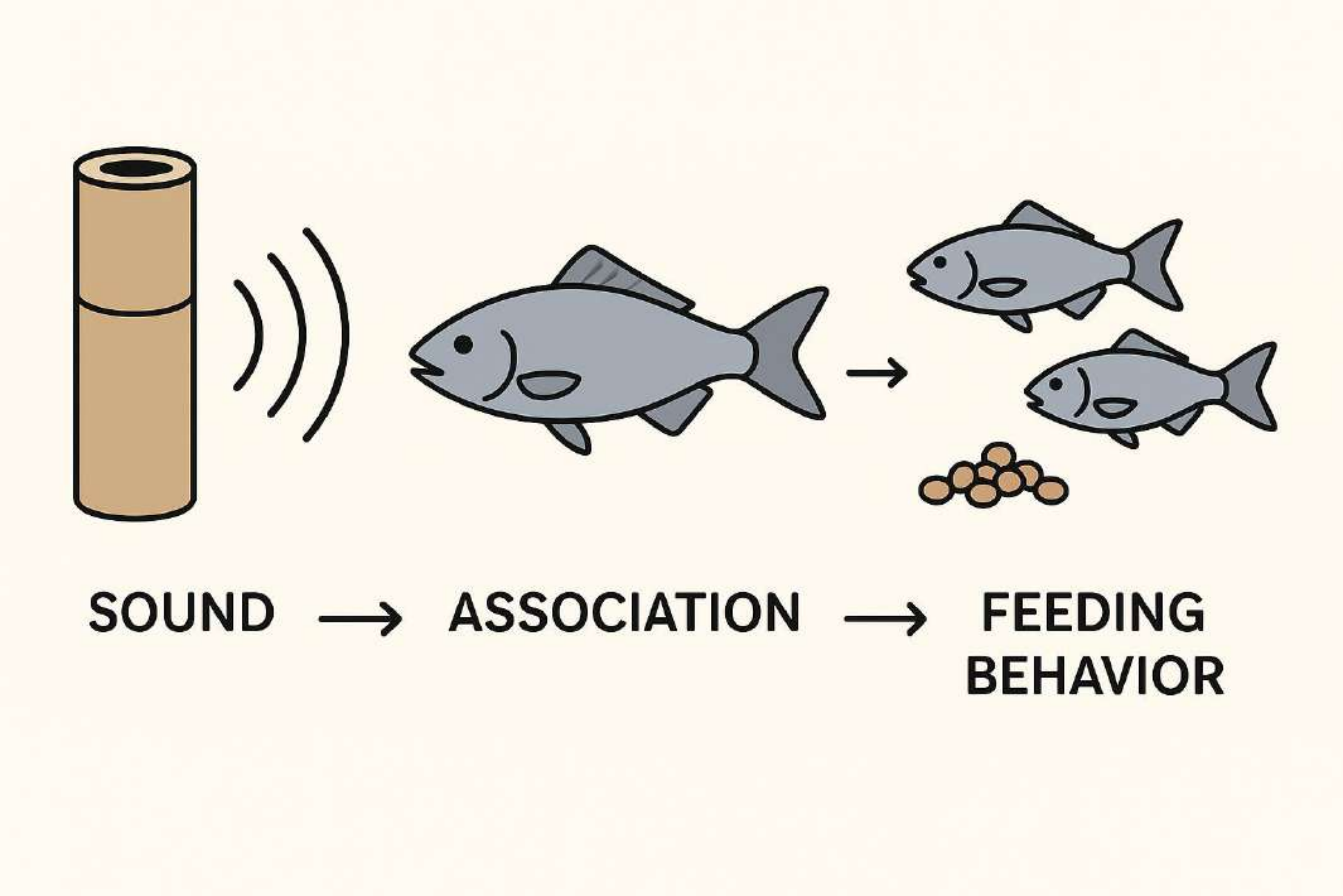
3.1. Feeding regime: time, frequency, ration, fasting, etc.

3.2. Psychological training: acoustic, vibration, visual, etc.

3.3. Simple attraction and expelling effect*: biochemical attractants and expellant (*selective feeding in polyculture?).

Does bamboo-knocking sound attract Koi carp gathering for feeding?

An example on artificial effect on fish feeding behavior



Reasoning for Fact

1. What the fish respond to

The gathering behavior of fish in response to bamboo knocking is **not** due to attraction to the bamboo sound itself by nature. Instead, it is the result of **conditioning (learning by association)**.

Over repeated feedings:
(1)The fish hear a consistent **auditory cue** (the bamboo knocking).
(2) Shortly after, **feed appears**.
(3)Their brains associate the sound with food availability.

This is **classical (Pavlovian) conditioning**—exactly like Pavlov’s dogs salivating when hearing a bell that predicts food. So, when fish rush toward the sound, it’s not curiosity about the sound—it’s **anticipatory feeding behavior** due to learned association.

2. Why use bamboo knocking

The **bamboo tube** produces a **deep, resonant knocking** that:

(1) Travels well both **in air and through water**.
(2) Is easily distinguishable from natural background noises (wind, waves, birds, etc.).
(3) Can be consistently reproduced by the farmer.

The **low-frequency vibrations** also transmit effectively underwater, which fish can detect through:

(1) The **lateral line system** (sensitive to vibration and pressure changes).
(2) Their **inner ears** (sensitive to sound).

Thus, the bamboo serves as a **clear and repeatable signal**—an ideal training cue.

3. The conditioning process

Fish farmers typically:
(1) Knock the bamboo **a few times** before each feeding.
(2) Repeat this **consistently** over many feedings.
(3) Fish gradually **learn the association**: "Sound→Food."
(4) Eventually, the sound alone is enough to make them gather near the feeding point.

4. Scientific parallels

This kind of **acoustic conditioning** has been documented in several species:
(1) **Tilapia**, **carp**, and **catfish** can learn to associate feeding with sound or vibration.
(2) In aquaculture research, **sound conditioning** has been used to **reduce feed waste** and **improve feeding efficiency**, as fish gather quickly and feed actively when they hear the cue.

5. Summary

Factor	Role
Bamboo echo	Physical sound carrier—distinct and transmits underwater.
Fish attraction	Not innate; learned through conditioning.
Mechanism	Auditory-vibrational cue triggers conditioned feeding behavior.
Benefit	Efficient feeding, reduced waste, easier management.

Conclusion:

The bamboo-knocking sound itself does not naturally attract fish. The attraction results from **repeated training**, where fish learn to associate that specific sound with feeding. It’s a classic example of **operant or Pavlovian conditioning** successfully applied in aquaculture.

key constraints (1/3) that aquafarms often face when adopting AI

1 Cultural and Psychological Resistance
1.1 Farmer Identity and Pride
1.2 Fear of Being Replaced

2. Financial Constraints & ROI Concerns
2.1 High Initial Investment
2.2 Skepticism About Payback

3. Skill Gaps and Training Needs
3.1 Low-Tech Literacy
3.2 Language and Interface Barriers

key constraints (2/3)

4. Infrastructure & Environmental Limitations
4.1 Connectivity Problems
4.2 Hardware Fragility

5. Data Limitations
5.1 Incomplete or inconsistent records
5.2 Lack of historical data to train prediction models

6. Trust, Control & Liability
6.1 Loss of Control
6.2 Accountability Concerns

Key Constraints (3/3)

7. Ethical & Social Impact

The last, but deserves the highest attention since:

If AI adoption leads to job displacement without retraining, it may widen inequality in rural communities.

Conversely, AI projects that exclude farmers from co-design may ignore important local knowledge—leading to failure.

How to Mitigate Those Constraints

Challenge	Suggested Approach
Farmer ego / pride	Involve farmers in AI **co-development**; respect their input as valuable training data.
Fear of job loss	Emphasize **AI as augmentation**, not replacement; offer **upskilling** programs.
ROI skepticism	Start with **pilot trials** and showcase **data-driven outcomes** before scaling.
Skill gaps	Provide **hands-on, local-language training** with real use cases.
Infrastructure issues	Use **offline-capable** or **edge-AI** tools; invest in rugged devices.
Trust concerns	Make AI decisions **transparent** and adjustable by humans.
Community disruption	Engage communities early and share benefits through **local cooperatives**.

Key Principals How to Make Farmers Your Friends Also AI Business Partners

What Works	What to Avoid
Co-create, not top-down	Imposing AI with no consultation
Show, don't tell	Only explaining AI benefits verbally
Speak their language	Using tech jargon without clarity
Respect experience	Assuming AI is smarter than humans
Offer gradual rollout	Forcing full adoption overnight

Artificial Intelligence, AI:
Teaching computers to learn and think like humans.

Computer		Human
Student Teacher		Teacher Student
Apprentice Master		Master Apprentice
Employee Employer		Employer Employee
Staff Officer Commander		Commander Staff Officer
…		…
Partners	**Brotherhood**	**Partners**

Let’s Enjoy the SPA!

Sustainable Precision Aquaculture


Thank you for your attention
Comments and questions are welcome