

Industry Standard for using Lumpfish (*Cyclopterus lumpus* L.) as Cleaner Fish in Atlantic Salmon Sea Pens



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Introduction

Cleaner fish have for a long time been considered a cornerstone in lice control strategies, but their use raises concerns around welfare, survival, and effectiveness.

This standard aims to align industry practices with evidence-based protocols that protect fish welfare while simultaneously improving delousing outcomes.

This version of the standard is meant to be used as a booklet, easily accessible on site, while the main paper, as well as the Operational Welfare Indicators (OWIs) manuals can be used for reference.

Hatcheries

The quality of lumpfish is already determined in the hatchery. Early decisions on light regimes, grading, and density directly affect lumpfish health and behavior in sea pens.

Critical Parameters

- Apply standardized rearing protocols in hatcheries
- Maintain optimal light cycles and intensity to reduce stress
- Control stocking density to minimize aggression
- Perform regular size grading to reduce competition
- Acclimatize to salmon, environmental conditions and feed cues before transfer



Checklist

- ✓ Perform biweekly welfare checks using OWIs
- ✓ Use behavioral scoring to identify aggression
- ✓ Which degree of acclimatization has been achieved?

Transfer of Lumpfish

Transferring lumpfish is a high-stress event. Stress, poor acclimation, or rough handling at this stage can lead to early mortality, reduced grazing, and long-term performance loss.

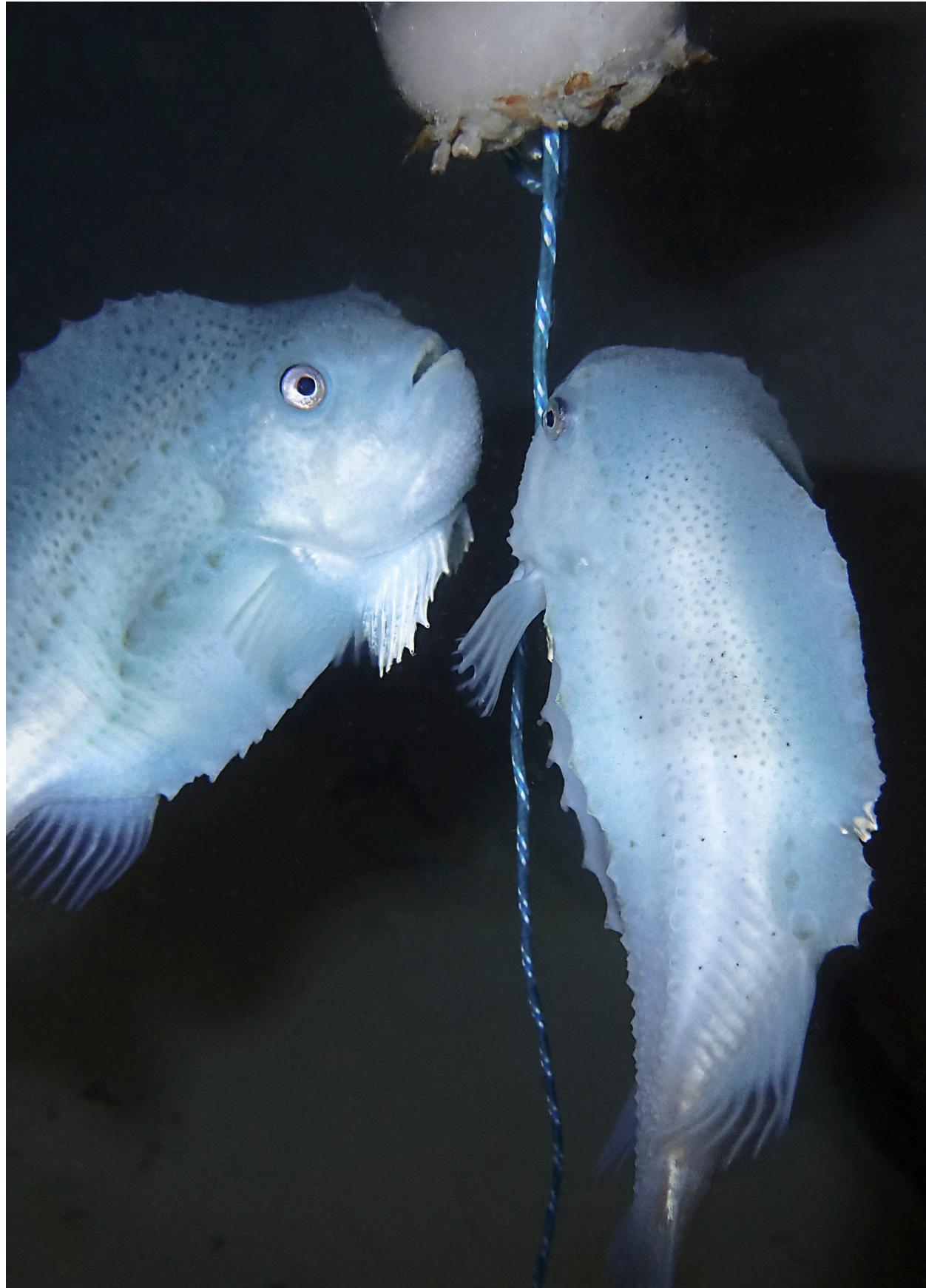
Critical Parameters

- Fasting period: 3 days prior to transfer
- Health screening: veterinary inspection + PCR test
- Gradual water temperature matching during loading



Checklist

- ✓ Ensure handover notes between hatchery, carrier and site
- ✓ Acclimation completed?
Gradual adjustment to temperature, salinity, current, odors, and light (3–5 days ideal)
- ✓ Fit-for-transfer fish only?
Exclude fish with injuries, deformities, or poor condition scores
- ✓ Gentle loading method used?
Use pumps or hoses with low pressure and soft bends. Avoid dry transfers
- ✓ Clean and oxygenated water during transport?
Maintain stable oxygen (> 90%), temperature, and avoid overcrowding
- ✓ Pen prepared?
Install shelters, verify net hygiene, ensure lice levels are low before stocking
- ✓ Monitor first 7 days post-transfer
Use Remotely Operated Vehicle (ROV) to assess behavior, distribution, and early OWI scores to catch issues early



Stocking Strategies

Effective stocking depends on fish size, temperature, and site exposure.

Critical Parameters

- Optimal stocking temperature < 14°C
- Use small fish < 40 g for best lice grazing
- Avoid sites exposed to high water currents



Checklist

- ✓ Assess season and temperature before deployment
- ✓ Align net mesh with stocking size
- ✓ Log survival and performance by pen

Feeding

Feeding strategies determine both survival and delousing performance. Overfeeding reduces lice appetite (Appendix 3).

Critical Parameters

- Feed 2–3% Body Weight (BW¹) during spring–autumn, 3–4% in winter (see Appendix 3)
- Use feed blocks to slow growth and prolong grazing window
- Feed blocks should always be available unless a deliberate fasting period has been planned and justified
- If feeding pellets, feed 3 times a week
- Keep the fish “lean and mean” to enhance lice grazing



Checklist

- ✓ Place feeding stations near or inside shelters
- ✓ Use multiple feeding points to reduce dominance and aggression
- ✓ Adjust rations based on biomass estimates (derived from stocking densities and average weight)

Shelters & Rest Areas

Shelters are essential for lumpfish welfare. They provide physical cover, rest zones, and reduce stress and aggression. Poor shelter design or placement reduces cleaner fish performance and increases mortality risk. Biofouling must be held to a minimum.

Critical Parameters

- Curtain shelters with ample surface area
- Clean every 7–20 days to prevent biofouling
- Position shelters to avoid disrupting salmon movement/block swimming passages



Checklist

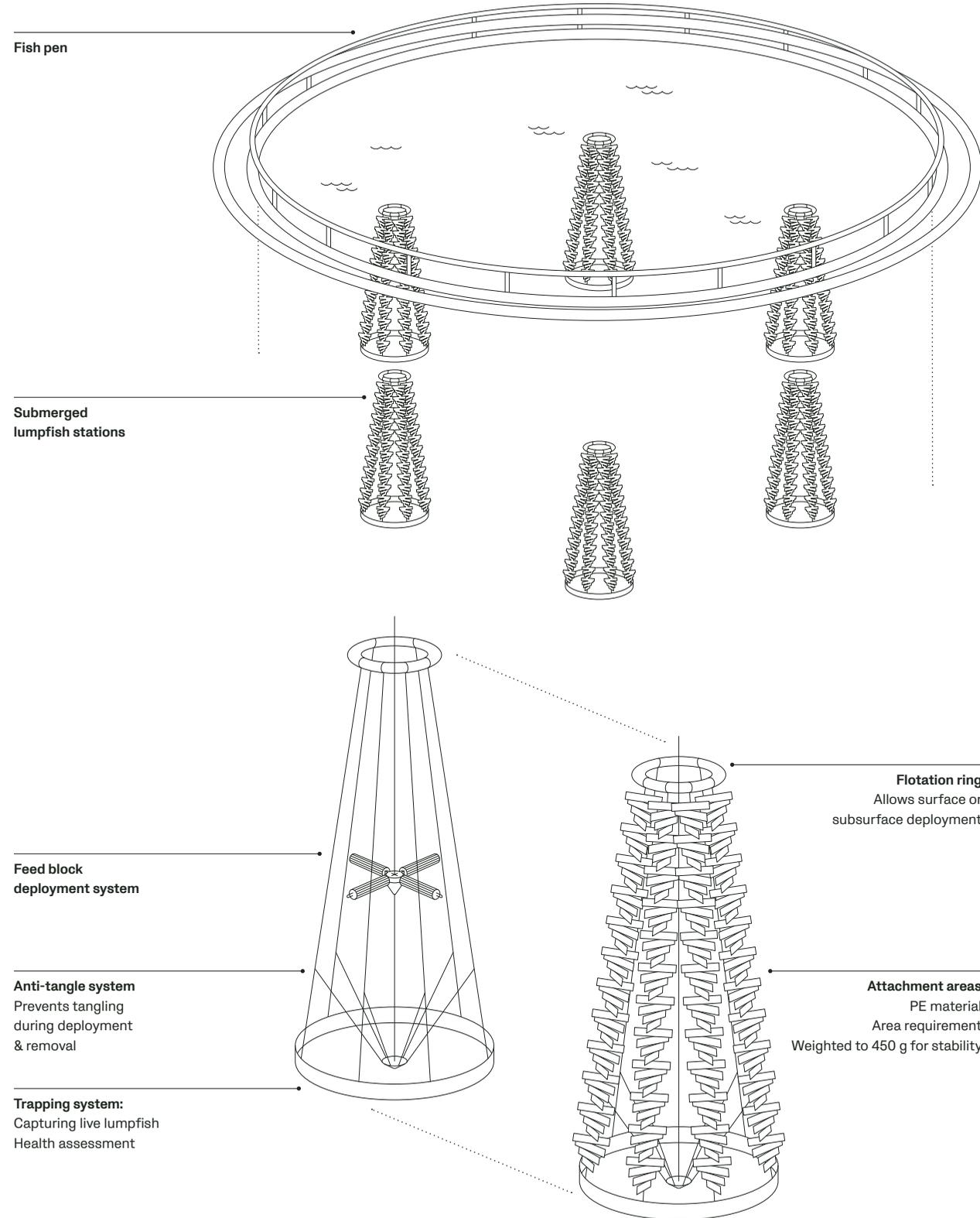
- ✓ Provide sufficient and appropriate surface area based on stocking density
- ✓ Inspect shelter biofouling regularly
- ✓ Maintain spacing between shelters and net walls as salmon entries
- ✓ Regularly observe pen environment and lumpfish/salmon interaction with a ROV



Field tip

Shelters are not hiding spots; they are functional infrastructure essential for lumpfish survival and lice grazing support. They must be integrated into system design and managed accordingly.

Suggestion for setup.
Submerged lumpfish stations with flotation, feeding, and trapping systems placed inside the fish pen for effective cleaner fish management.



Health Screening

Routine health screening is essential to ensure the welfare and performance of lumpfish throughout the production cycle.

Using structured OWI, site staff can identify early signs of stress, disease, or poor adaptation – and take corrective action before serious welfare or functional issues develop.

The indicators used are primarily external and non-lethal, allowing assessments to be performed in the pen with minimal handling.

The goal is not just to detect illness, but to actively manage fish welfare based on measurable, observable criteria – ensuring

lumpfish remain healthy, motivated to graze lice, and fit for purpose.

For practical guidance and scoring criteria, field forms (Appendix 1 & 2) and screening manuals (from the FHF-funded *Dokumentar* and *Effektiv* projects) can be downloaded at <https://aqua-kompetanse.no/lumpfish/>. See Table 1 for a summary of key indicators used during routine health checks.



TABLE 1.

This checklist summarizes key indicators used during routine health screening of lumpfish in sea pens. It supports early detection of welfare issues and helps standardize observations across sites. Scores are based on OWI principles and practical field guidance.

PARAMETER	NORMAL (SCORE 0)	FLAG FOR ACTION (SCORE ≥1 OR CRITICAL)
Body condition	Well filled out, no emaciation	Emaciated (score 2–3), rapid decline
Skin	No damage or lesions	Ulcers, Tenacibaculum-type wear, open wounds
Fins (caudal/pectoral)	No erosion, full shape	Eroded, split or missing fin tissue
Eye condition	Clear, no bleeding	Blood in eye, swelling, cloudy cornea
Cataracts	No visible opacity	Lens coverage ≥30%, bilateral cataracts
Deformities	None (sucker, spine normal)	Malformed sucker-disc, bent spine, gill deformity
Liver color (post-mortem)	Pale or orange	Dark red, brown, mottled
Ascites / Fluid	No fluid in cavity	Free fluid in abdomen, distension
Internal parasites	None visible	Nematodes, cestodes, gill amoeba
Stomach content	Zooplankton or lice	Exclusively salmon feed, empty gut

Sampling Routine

- Screen at least 10 fish per pen bi-weekly
- Use OWI scoring for consistent tracking
- Autopsy 2–3 fish if field indicators show warning signs
- Record all welfare findings in the site welfare log for future analysis

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Restocking & Removal

Following regulations, lumpfish must be removed before mechanical delousing. Restocking or moving between pens must follow welfare and legal guidelines.

Critical Parameters

- Plan removal 5+ days before treatment
- Select method based on fish size class
- Use certified recapture teams where possible



Checklist

- ✓ Use feed lures or specialized trawls
- ✓ Log fish removed and retained per pen
- ✓ Avoid inter-site transport unless permitted

Sea Lice Grazing Efficacy

Lice grazing varies across individuals and is affected by fish size, health, and motivation. Monitoring is key.

Critical Parameters

- Best grazing in small, lean lumpfish (20-40 g)
- Use trained / selected strains if available
- Monitor grazing behavior in sea pens using a ROV
- Avoid relying on lumpfish alone – integrate in multi-method strategies



Checklist

- ✓ Monitor grazing signs on salmon
- ✓ Record lice levels before and after cleaner fish use to compare trends
- ✓ Identify pens with low grazing activity

Combination Strategies

Lumpfish don't work well in isolation – but they also can't work under stress. Design your lice strategy around compatibility, not just convenience, as poor integration reduces effectiveness.

Critical Parameters

- Lice skirts may limit vertical overlap between lumpfish and salmon, use ROV to confirm behavioral integration with salmon
- Align stocking strategies with tech: avoid deploying cleaner fish in heavily automated pens unless proven compatible
- If using in combination with optical delousing, ensure the lumpfish shelters are positioned away from the lasers



Checklist

- ✓ Confirm vertical overlap when using lice skirts (esp. in warm or layered water)
- ✓ Monitor behavior and welfare weekly with a ROV when combining methods
- ✓ Ensure the combining methods do not interfere with each other in a negative manner

End-of-Cycle Assessment

At the end of each production cycle, evaluate lumpfish welfare and effectiveness to determine whether to continue, adjust, or discontinue use. Review mortality, lice control, behavior, feeding, and compatibility with other tools.



Checklist

- ✓ Mortality < 5%?
Acceptable range. Higher values require review (e.g. feeding, handling, transfer)
- ✓ Lice control effective?
Compare pens with and without lumpfish
- ✓ Active behavior and shelter use observed?
Frequent visibility and interaction with salmon = good welfare
- ✓ Removal/reuse successful?
Record % recaptured before delousing and removal method
- ✓ Feeding supported grazing?
Feeding should maintain motivation to graze, not just growth
- ✓ OWI scores acceptable?
Look for signs of cumulative stress or deterioration (e.g. cataracts, fin erosion, condition loss)
- ✓ Technology compatible?
Noticed any conflicts with skirts, lasers, or delousing infrastructure

Decision for Next Cycle

- Continue same approach
- Adjust density, strategy, timing
- Try alternative methods
- Discontinue lumpfish use



Knowledge Gaps

Despite advances in cleaner fish use, several important questions remain. These knowledge gaps highlight areas where further research, monitoring, or standardization is needed. Field teams are encouraged to document observations and report relevant findings through internal systems. For detailed discussion, refer to section 12 of the Lumpfish Industry Standard.

Unresolved Questions

- Environmental exposure thresholds
- Impact of zooplankton blooms on lumpfish health and grazing
- Behavioral interaction and depth overlap with salmon
- Impact and consistency of current vaccine protocols
- Effectiveness and welfare risk of different removal methods
- Relationship between stocking density and aggression/mortality
- Long-term impact of selective breeding on lice grazing

Lumpfish require specific husbandry practices to maintain health and sea lice grazing efficacy. If these requirements are not met it is likely that welfare will become compromised and may lead to increased mortality. In addition, once welfare becomes compromised then potential for sea lice grazing efficacy decreases. At this point continued use of lumpfish is inadvisable as the cost-benefit is no longer justifiable and therefore, alternative preventative measures must be employed to control sea lice infestations.

Appendix

Appendixes 1 & 2 are field forms for filling out the OWI for lumpfish, either in hatchery or on sea sites. Appendix 3 is an example of a feeding plan.

APPENDIX 1.
Field Form Lumpfish
Hatchery

Facility	Area														
Fish group	Tank	Date													
	OWI, Fish #														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Weight (g)															
Length (cm)															
Suction cup deformity (0-3)															
Other deformities(0-3)															
Caudal fin (0-3)															
Other fins (0-3)															
Skin (0-3)															
Eye L (0-3)															
Eye R (0-3)															
Cataract L (0-3)															
Cataract R (0-3)															
	Autopsy, Fish #														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Liver colour (1-6)															
Ascites (0-1)															
Changes in the liver (0-1)															
Granuloma (0-1)															
Swollen kidney (0-1)															
Bleeding on the heart (0-1)															
Coagulation in heart cavity (0-1)															
Bleeding stomach/intestine (0-1)															
Parasites (0-1)															
Sex (1 -2)															
Sampling - PCR (x)															
Sampling- Blood sample (x)															
Sampling - Histology (x)															
Sampling - Bacteriology (x)															
Comments:															

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APPENDIX 2.
Field Form Lumpfish
Sea Pens

Facility	Cage															Date
	OWI, Fish #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Weight (g)																
Length (cm)																
Suction cup deformity (0-3)																
Other deformities (0-3)																
Caudal fin (0-3)																
Other fins (0-3)																
Skin (0-3)																
Eye L (0-3)																
Eye R (0-3)																
Cataract L (0-3)																
Cataract R (0-3)																
	Autopsy, Fish #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Liver colour (1-6)																
Ascites (0-1)																
Changes in the liver (0-1)																
Granuloma (0-1)																
Swollen kidney (0-1)																
Bleeding on the heart (0-1)																
Coagulation in heart cavity (0-1)																
Bleeding stomach/intestine (0-1)																
Parasites (0-1)																
Sexual maturation (0-1)																
Sex (1 -2)																
Lumpfish pellets (0-1)																
Feedblocks (0-1)																
Salmon pellets (0-1)																
Zooplankton (0-1)																
Biofouling (0-1)																
Other (0-1)																
Salmon lice- Number																
C. elongatus- Number																
Lice unidentified. - Number																
Sampling - PCR (x)																
Sampling - Blood sample (x)																
Sampling - Histology (x)																
Sampling - Bacteriology (x)																
Comments:																

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APPENDIX 3.

This table provides a side-by-side comparison of recommended feeding rates and operational guidance for lumpfish in summer and winter conditions. Adjust for local water temperature, fish size, and feeding behavior.

PARAMETER	SUMMER (SPRING-AUTUMN)	WINTER (COLD SEASON)
Feeding rate	2-3% of biomass/day	3-4% of biomass/day
Feeding frequency	3x per week or continuous via blocks	4x per week or daily if possible
Feed type	Feed blocks (slow release) or pellets	Feed blocks recommended; avoid overfeeding pellets
Behavioral aim	Support lice grazing, moderate growth	Maintain condition, support lice grazing
Feed positioning	Near and inside shelters	Near and inside shelters
Estimated feed (10,000 fish @ 30g)	7.5 kg/day	9-12 kg/day
Estimated feed (25,000 fish @ 30g)	18.75 kg/day	22.5-30 kg/day
Recommended feed points	4-6 blocks	5-8 blocks
Monitoring	Weekly behavior check	Bi-weekly check, adjust if uneaten feed observed

