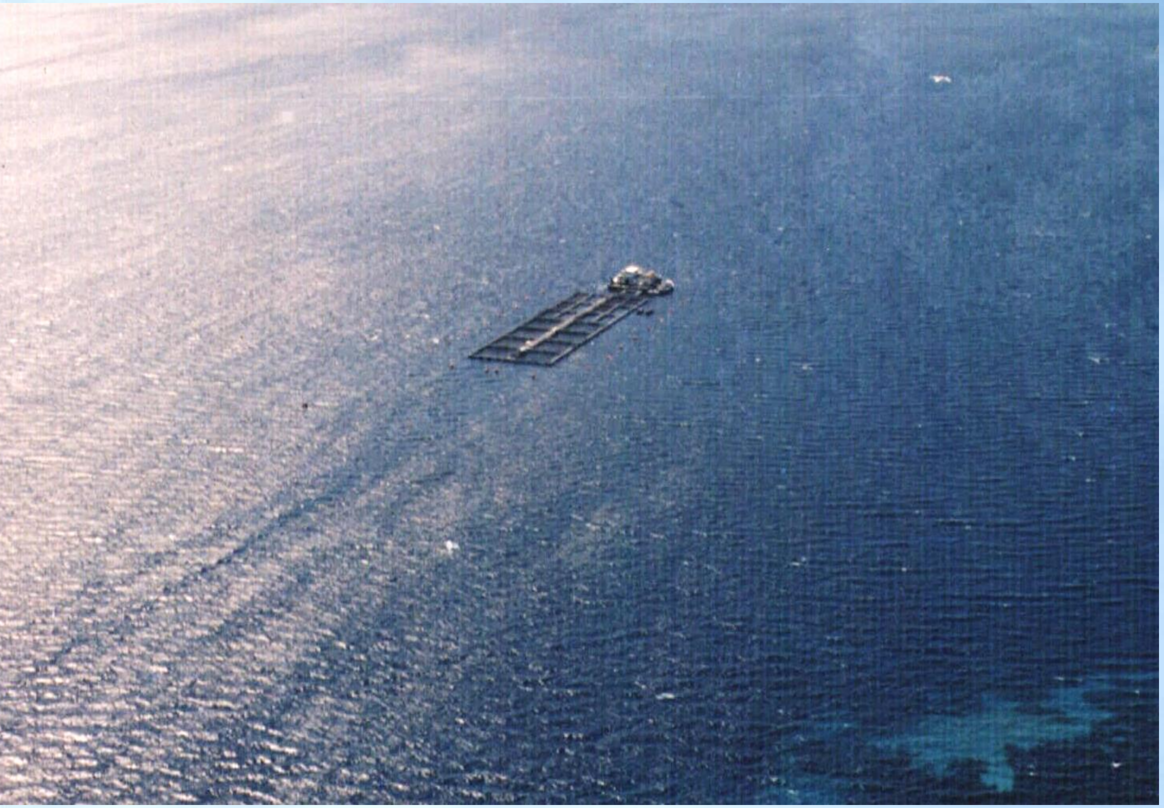
# Key Elements for Setting-up and Operating an Open-Sea Fish Farm: European Examples.

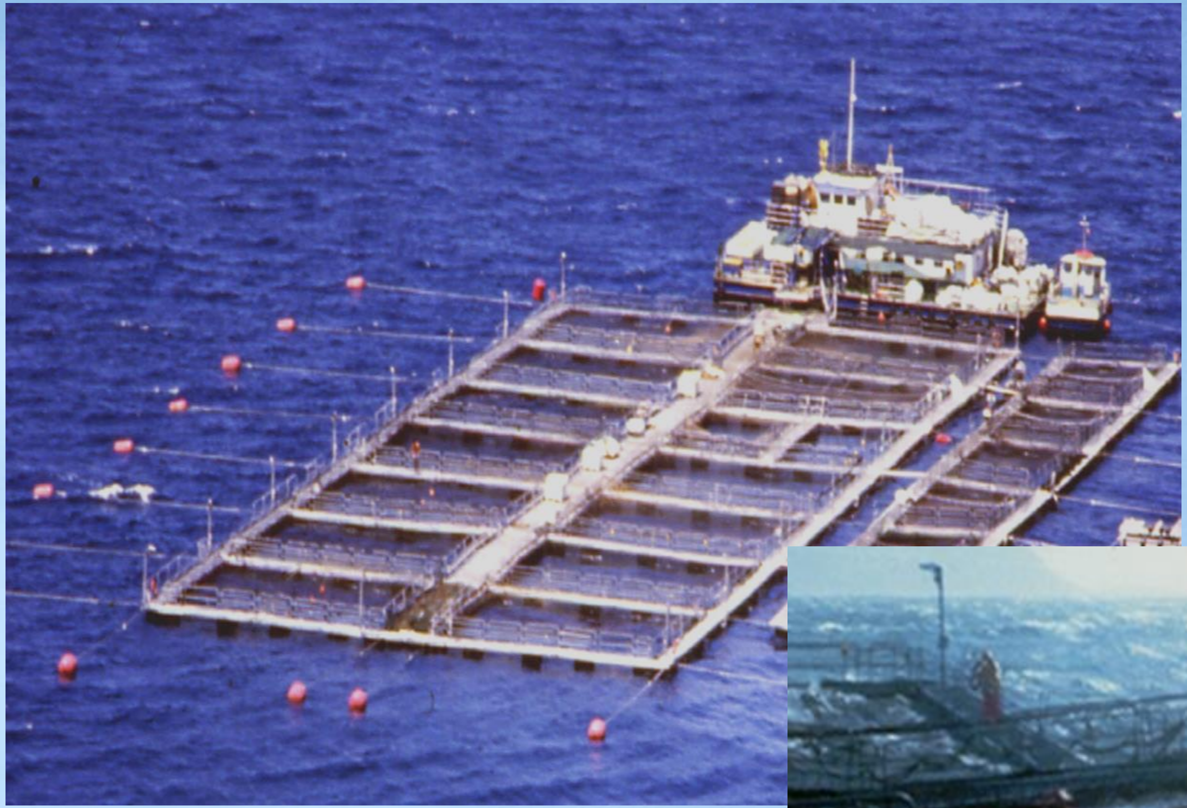
Darko Lisac
REFA MED Italy
*www.refamed.com*

Offshore Mariculture Asia 2018 Conference

## 1. **HOW IT STARTED ?**

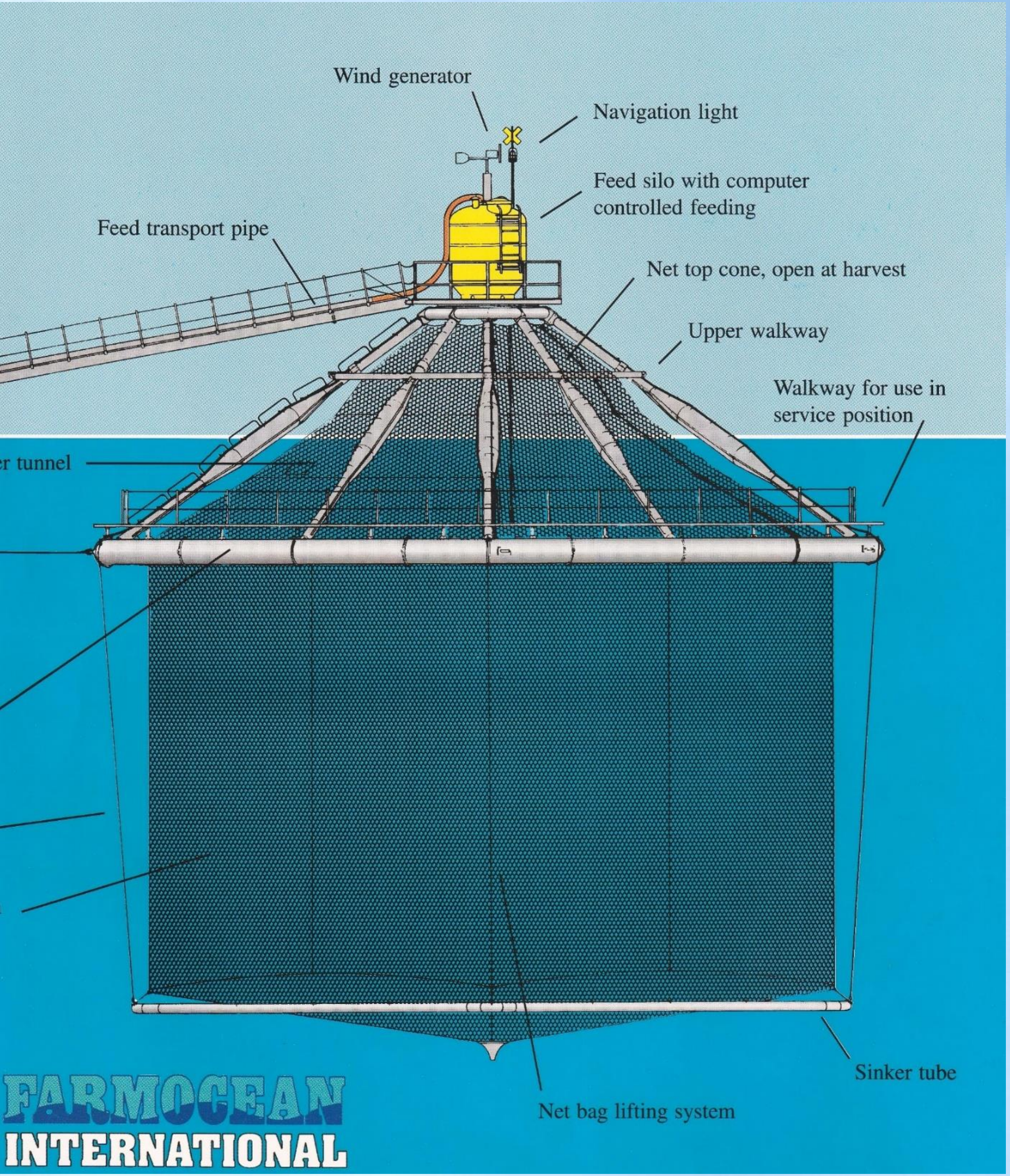
In the Mediterranean Sea, this was one of the 1st farms to move towards open waters (Italy1991).





Steel cage constructions were popular at the time.

# FarmOcean was one of the market leaders.



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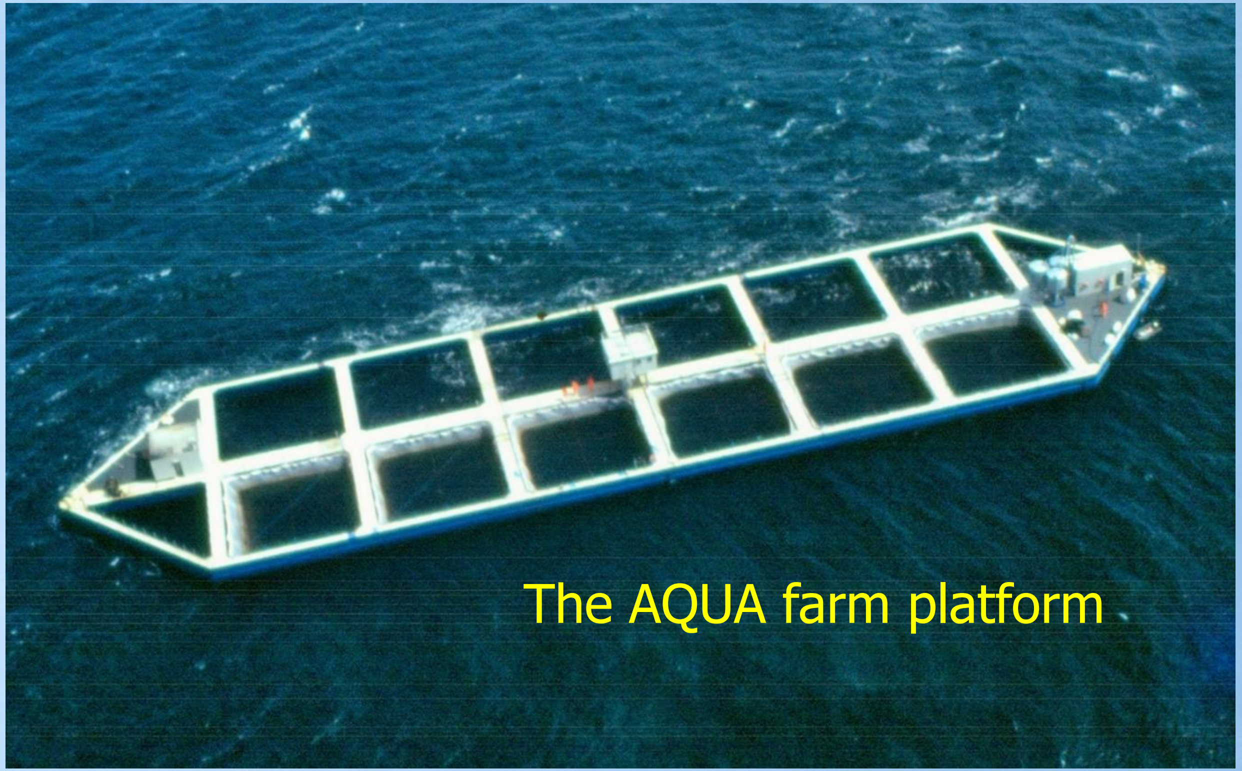
Steel structures do suffer from Rust,

But even more from material "fatigue" with age.



The AQUA farm platform

Rubber-hose Bridgestone & Dunlop cages constituted the 1st generation of flexible offshore fish-pens.

This heralded the move from rigid steel, to flexible structures that adsorb and move with the sea motion.

Floating PE cages increased in size, strength, and ability to withstand very exposed marine sites,

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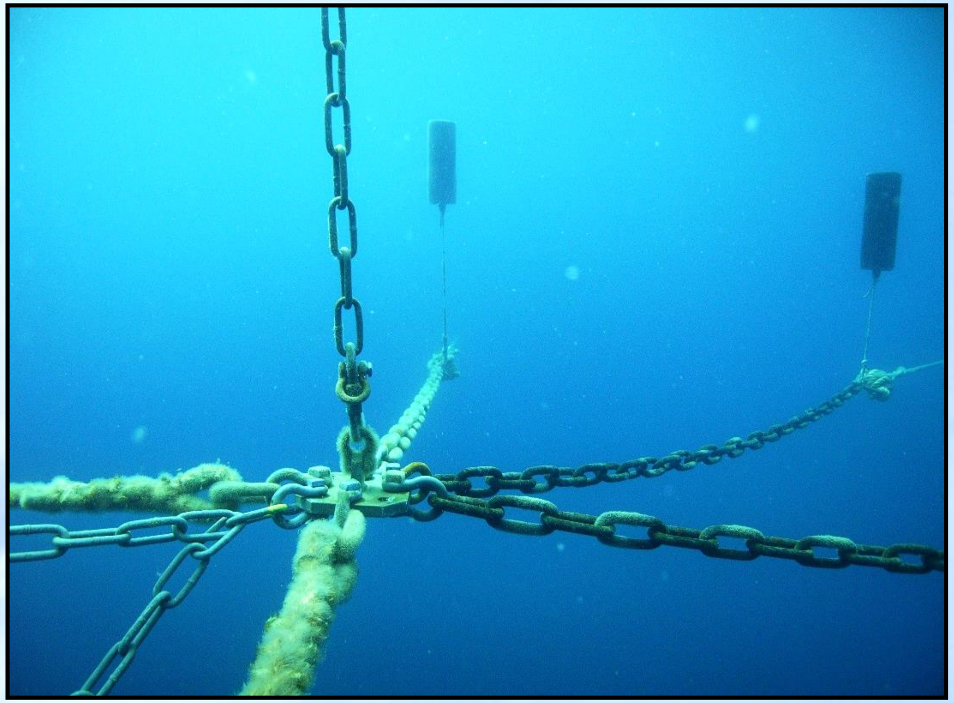
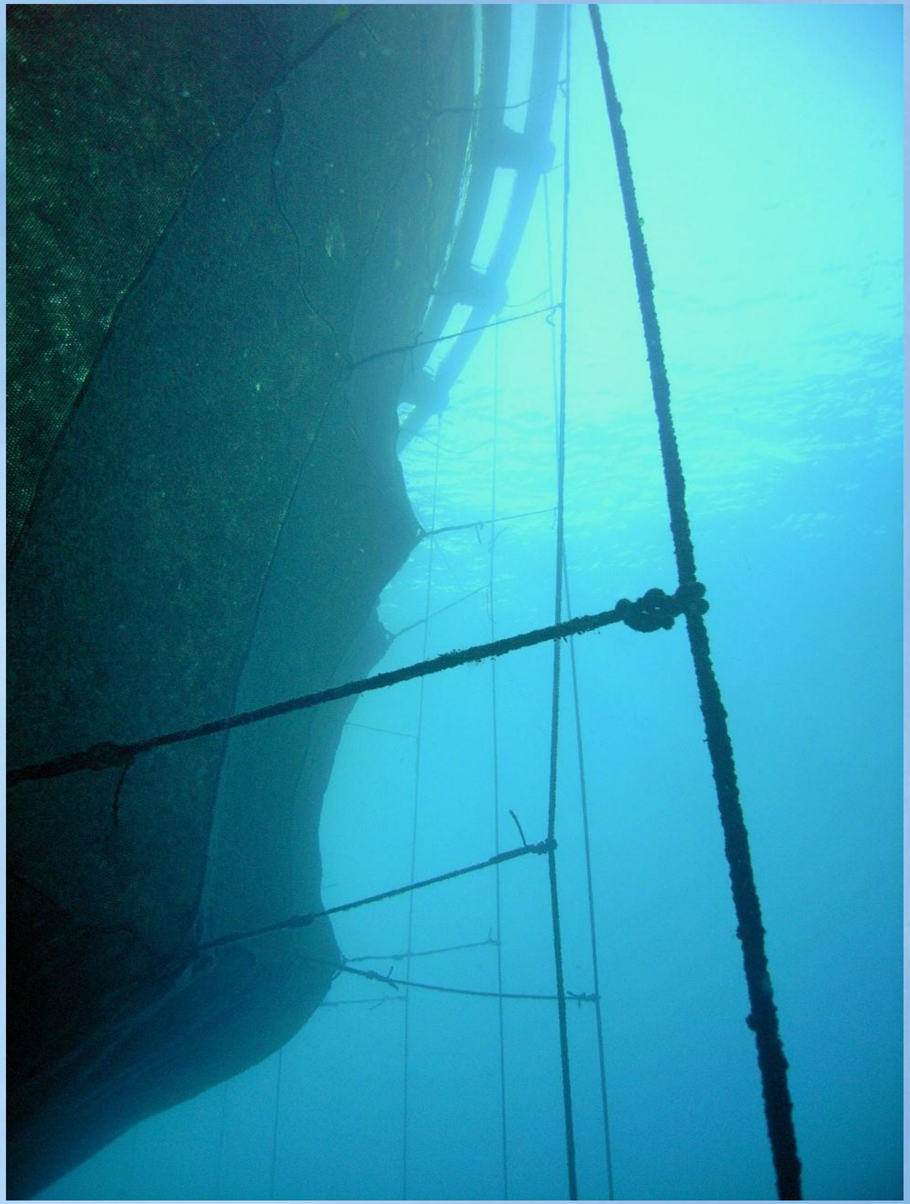


The configuration of the mooring system and net-pen design play a crucial role.



In the mid 1990s we introduced the first Tension Leg Cages, installed at site with 2000 km open-sea fetch to the West.

26 FISH FARMING INTERNATIONAL AUGUST 1996

CAGES IN FARMING

# Sea farm off Sicily installs Refa Tension Leg system

**With a central position in the Mediterranean, Italy has 8000 km of coastline but lacks sheltered areas suitable for traditional cage farms. The first floating cages were installed in semi-exposed sites in 1992 followed by open-sea installations from 1994 onwards. A recent project to install Norwegian Refa Tension Leg cages at a sea bass and sea bream farm in Sicily is described by DARKO LISAC of Maraqua Ltd.**

THE EOLIAN Archipelago comprises seven scattered volcanic islands off NE Sicily, 20-70 nautical miles from the port of Milazzo.

They rise up high from a seabed over 1000 meters deep, bathed in crystal clear waters at all times. Fisheries and tourism have long been the main earners. But decline in natural stocks and recent EU legislation are limiting traditional fishing of large pelagics like swordfish, tuna and yellowtail.

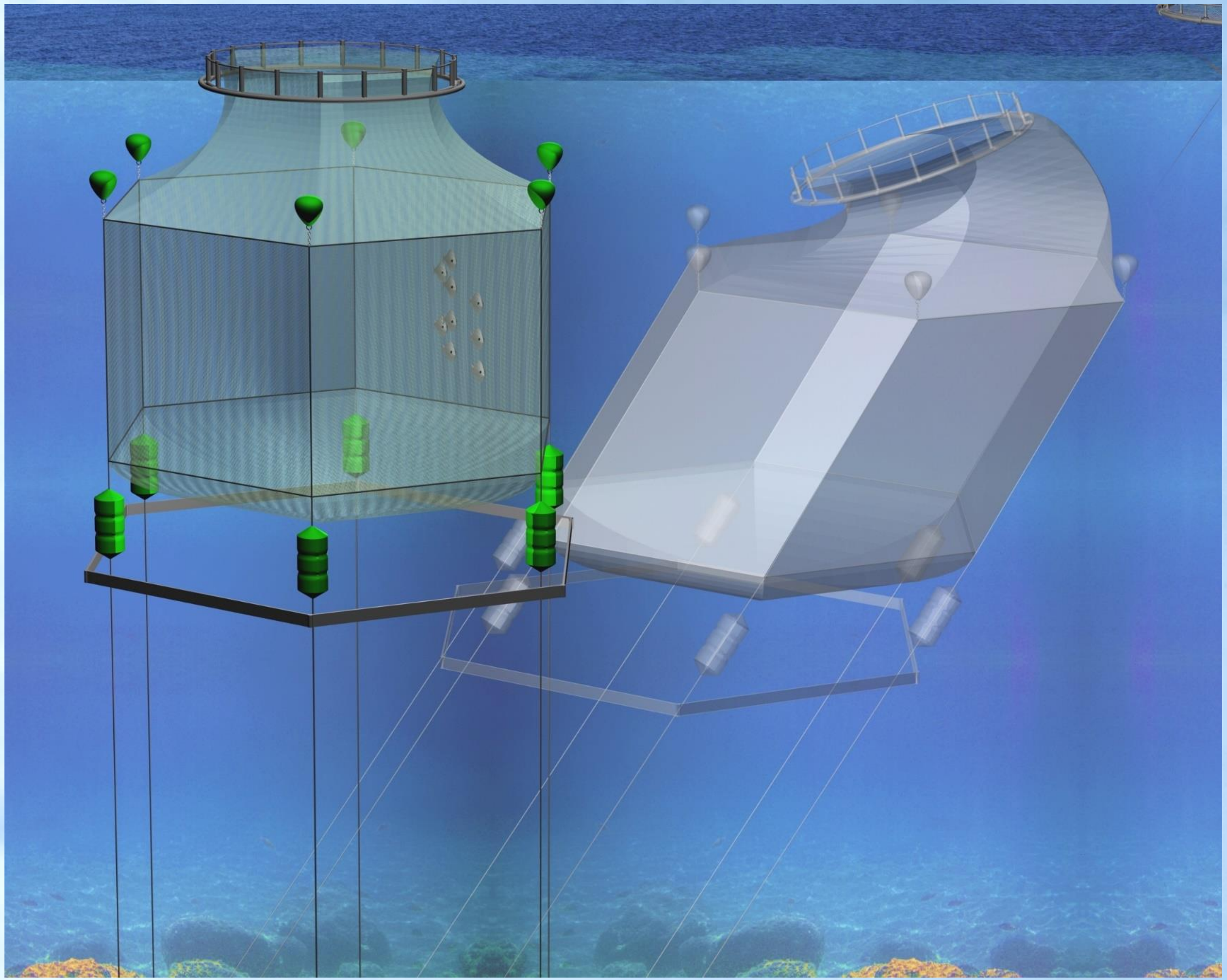
The local community is therefore looking into ways to develop a viable local marine farming industry as a substitute for fisheries.

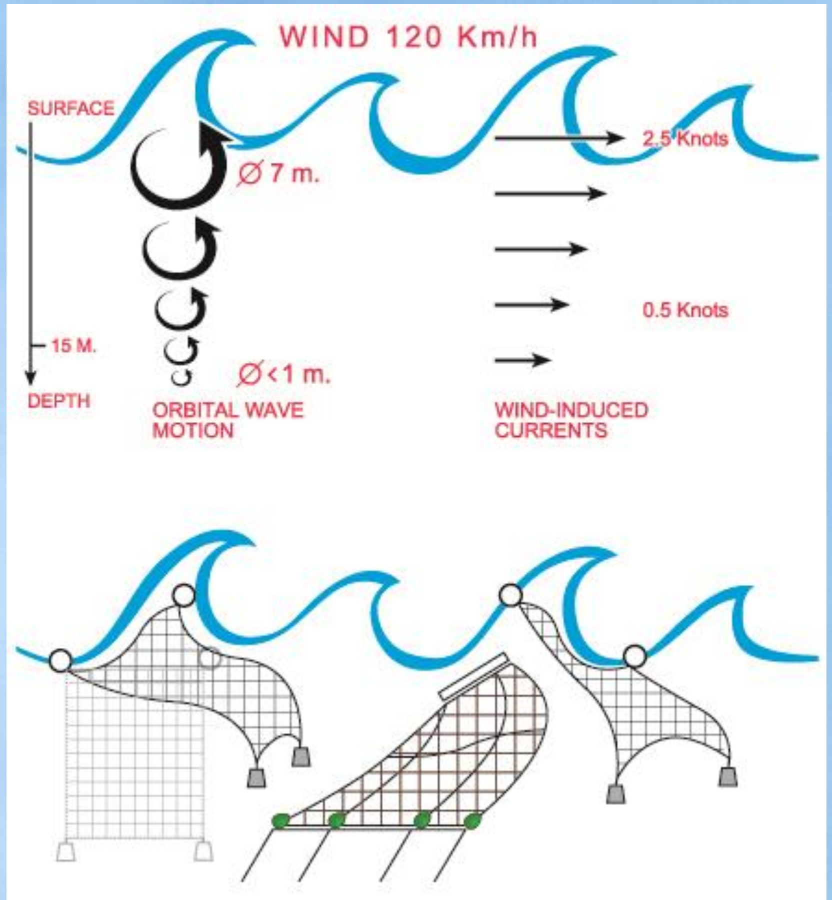
A group of private investors led by Nando Rossini, planning to set-up a small farm, applied for a site on the Island of Filicudi. They commissioned Maraqua to analyse the technical options for developing the project with an initial production capacity of 100 metric tons of bass, bream and yellowtail.

Filicudi has an area of nine sq. km; it is 770 metres high, and the surrounding seabed slopes downwards at a 40 degree angle.

The area available for the farm was initially described as sheltered, not subject to strong currents, and with a large extension of relatively flat seabed. Unfortunately no detailed maps with depth soundings were available. From the first field visit it became clear that the best site available was exposed and subject to an open-sea fetch of almost 2000 km in the west direction. There is a limited area 25-38 m deep with a slope of 20 per cent, the seabed being a mixture of coarse sand, rocks and algae.

The innovative design of the Tension Leg Cages exploits the marine forces to submerge during storms, rather than opposing the sea motion.





# 2. **SITE STUDY**

Essential to assess the prevailing and extreme conditions in terms of:

- Winds
- Waves
- Currents

| **Analysis of Marine Conditions** | | | | | | Candidate Site No 1. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wind direction from | Frequency in Percentage | | | | Fetch (km) | Frequency in Percentage | | | | |
| | Total frequency | Wind strength in Beauforts | | | | Maximum wave height (m) | | | | |
| | | 1 - 3 | 4 - 6 | 7+ | | < 1 | 1 - 2 | 2 - 4 | 4 - 6 | > 6 |
| 000 | 3,7 | | | | | 3,7 | | | | |
| N | 12,3 | 11,8 | 0,5 | 0,0 | 10 | 11,8 | 0,0 | | | |
| NNE | 8,8 | 8,7 | 0,1 | 0,0 | 4 | 8,8 | 0,0 | | | |
| NE | 14,4 | 14,4 | 0,0 | 0,0 | 3 | 14,4 | 0,0 | | | |
| E | 4,0 | 4,0 | 0,0 | 0,0 | 2 | 4,0 | | | | |
| SE | 6,1 | 5,1 | 1,0 | 0,0 | 2 | 6,1 | | | | |
| S | 6,4 | 5,9 | 0,5 | 0,0 | 1300 | 4,8 | 1,1 | 0,3 | 0,2 | |
| SW | 5,9 | 5,5 | 0,3 | 0,1 | 1600 | 4,6 | 0,9 | 0,2 | 0,1 | 0,1 |
| W | 18,6 | 15,5 | 2,9 | 0,2 | 1100 | 15,5 | 1,5 | 0,6 | 0,3 | 0,4 |
| NW | 20,4 | 17,4 | 3,0 | 0,0 | 350 | 17,4 | 1,7 | 0,8 | 0,5 | |
| Sum of conditions | | | Number of days /year | | | 334 | 19 | 7 | 4 | 2 |

**CONCLUSIONS**

| | | |
|---|---|---|
| For | 353 | days /yr the farm is fully operative |
| For | 7 | days /yr is difficult to reach the farm, & feeding is reduced |
| For | 4 | days /yr it is not possible to feed the fish nor reach the farm |
| For | 2 | days /yr there may be danger of damages to the farm facilities |

Magnitude
Vs.
Frequency

# 2. SITE STUDY

Less extreme Wave height, but 25% of the time farm not fully operational.

| Preliminary Analysis of Marine Conditions | | | | | | | Site No 2. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wind direction from | Frequency in Percentage | | | | | Fetch (km) | Frequency in Percentage | | | | |
| | Total frequency | Wind strength in Beauforts | | | | | Maximum wave height (m) | | | | |
| | | 1 - 2 | 3 - 4 | 5 - 6 | 7+ | | < 1 | 1 - 2 | 2 - 4 | 4 - 6 | above 6 |
| 000 | 1,7 | | | | | | 1,7 | | | | |
| N | 4,9 | 3,5 | 1,2 | 0,2 | 0,0 | 170 | 3,5 | 1,2 | 1,0 | | |
| NNE | 44,7 | 13,0 | 17,0 | 14,4 | 0,3 | 550 | 10,7 | 12,0 | 15,9 | 5,1 | 0,0 |
| NE | 16,0 | 5,5 | 6,0 | 4,5 | 0,0 | 15 | 12,0 | 4,0 | | | |
| E | 1,5 | 1,5 | 0,0 | 0,0 | 0,0 | 2 | 1,5 | | | | |
| SE | 4,3 | 2,8 | 1,0 | 0,5 | 0,0 | 3 | 4,3 | | | | |
| S | 13,1 | 6,6 | 5,0 | 1,5 | 0,0 | 5 | 13,1 | | | | |
| SW | 5,1 | 2,5 | 2,3 | 0,3 | 0,0 | 1600 | 1,5 | 0.7 | 2,0 | 1,3 | |
| W | 4,0 | 2,7 | 1,2 | 0,1 | 0,0 | 310 | 2,7 | 1,2 | 0,1 | | |
| NW | 4,9 | 2,6 | 2,0 | 0,3 | 0,0 | 90 | 3,6 | 1,0 | 0,3 | | |
| Sum of conditions | | Number of days /year | | | | | **199** | **71** | **70** | **23** | **0** |

**CONCLUSIONS**

| | | |
|---|---|---|
| For | **270** | **days /yr the farm is fully operative** |
| For | **70** | **days /yr is difficult to reach the farm, & feeding is reduced** |
| For | **23** | **days /yr it is not possible to feed the fish nor reach the farm** |
| For | **0** | **days /yr there may be danger of damages to the farm facilities** |

Magnitude
Vs.
Frequency

# 2. SITE STUDY

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## Other Major Factors to Assess:

- Seabed topography & composition
- Infrastructure / availability of skilled seamen / service
- Proximity to harbour / site accessibility & sailing time
- Risks such as Typhoons / Plankton Blooms
- Marine Predators

## Feeding:

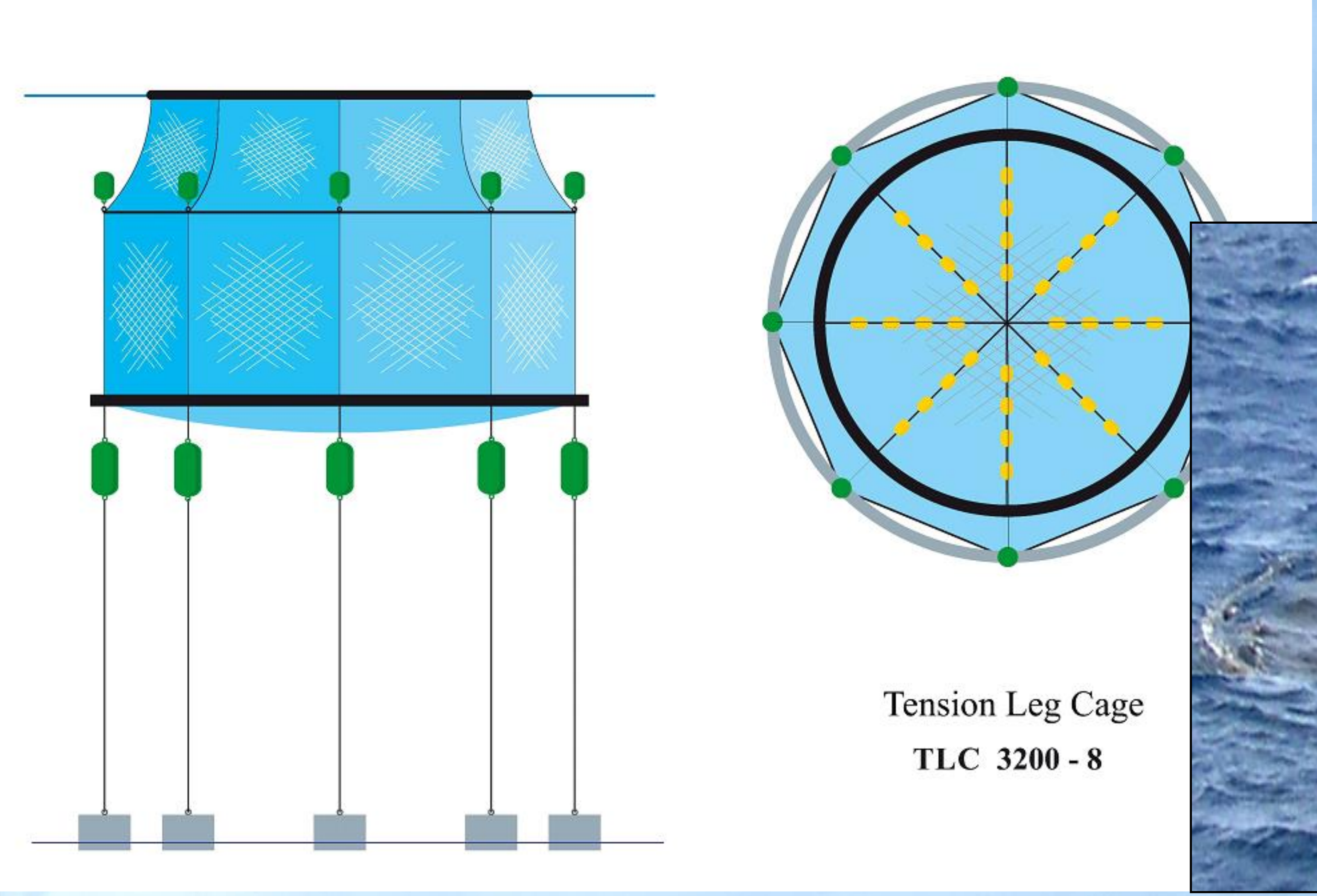
- Can automated feeding systems be installed ?
- Feed Barges / Feed Buoys / Feed Boats

## Fish Harvest:

- Regularity of Market supply ?
- Dedicated harvest cages / harvest site.

# 3. **OPERATIONAL ASPECTS**

## Examples from Tension Leg Cage (TLC) farms




# 3. **OPERATIONAL ASPECTS**

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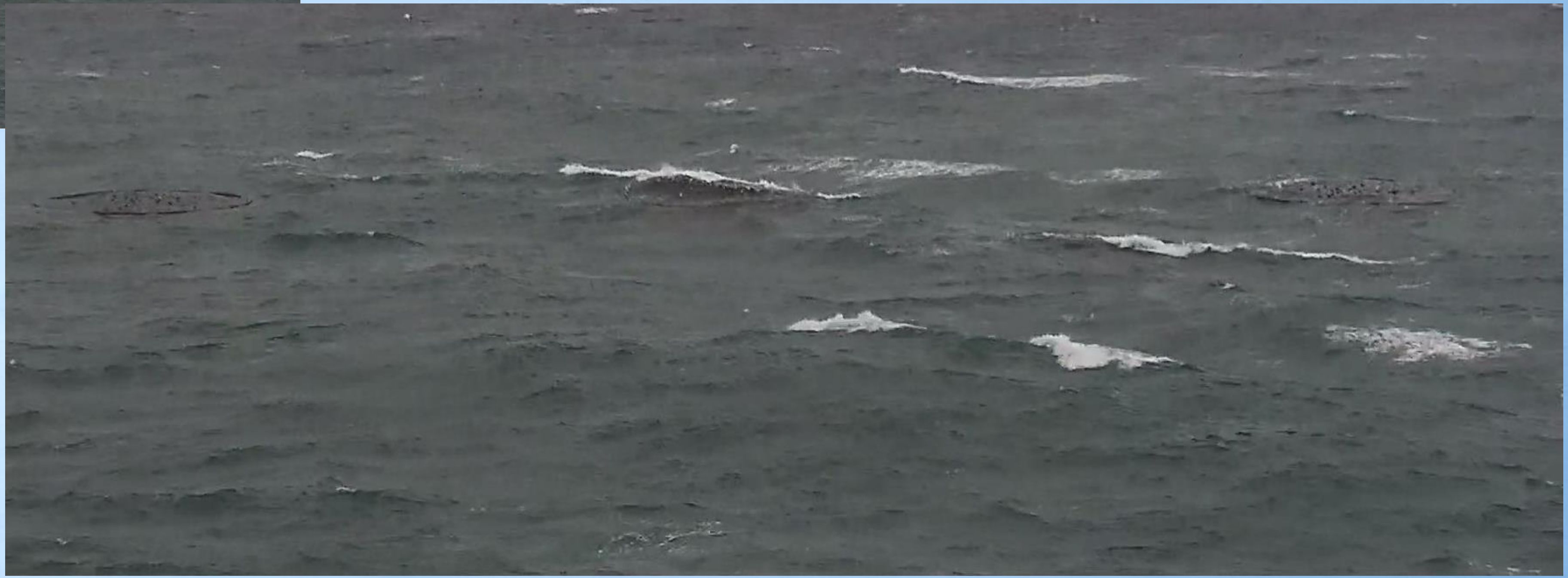
Examples from Tension Leg Cage (TLC) farms

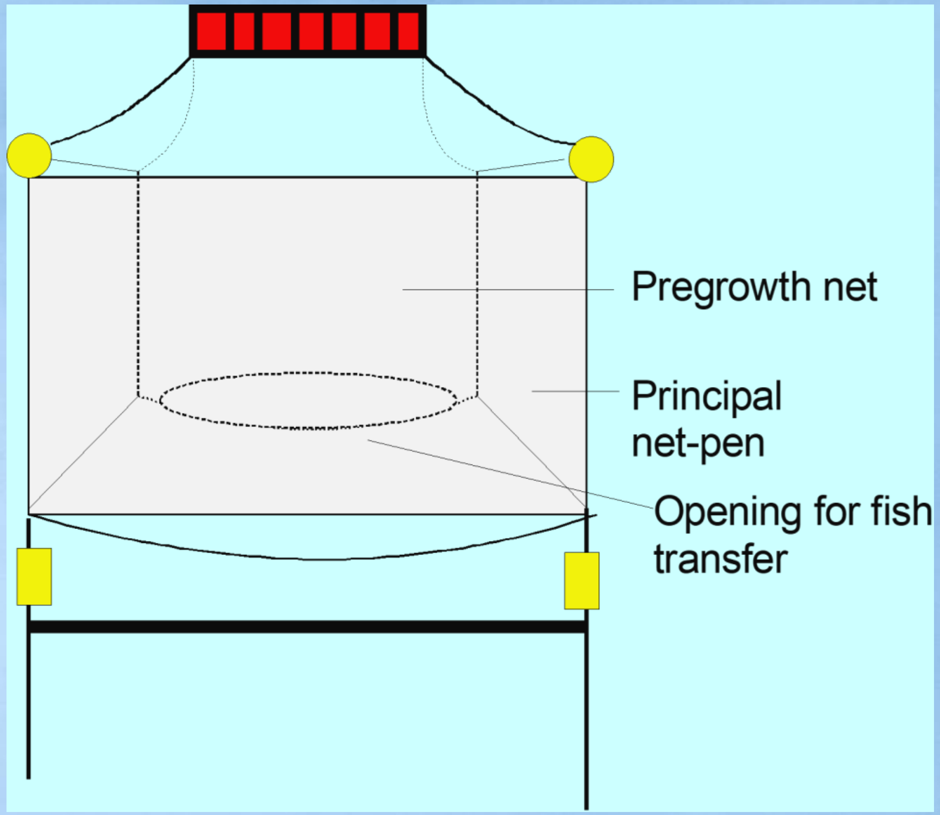



# 3. OPERATIONAL ASPECTS

## 3.1 Stocking Juveniles & Nursery Rearing

Size: 3 g / 10 g / 50+ g

Fry transport tanks




Internal Pregrowth Net

# 3. **OPERATIONAL ASPECTS**

Transfer from Nursery to main TLC cage net, at 20 g size

# 3. OPERATIONAL ASPECTS

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Transport of pre-grown, 50 g juveniles to farm site with transfer cage

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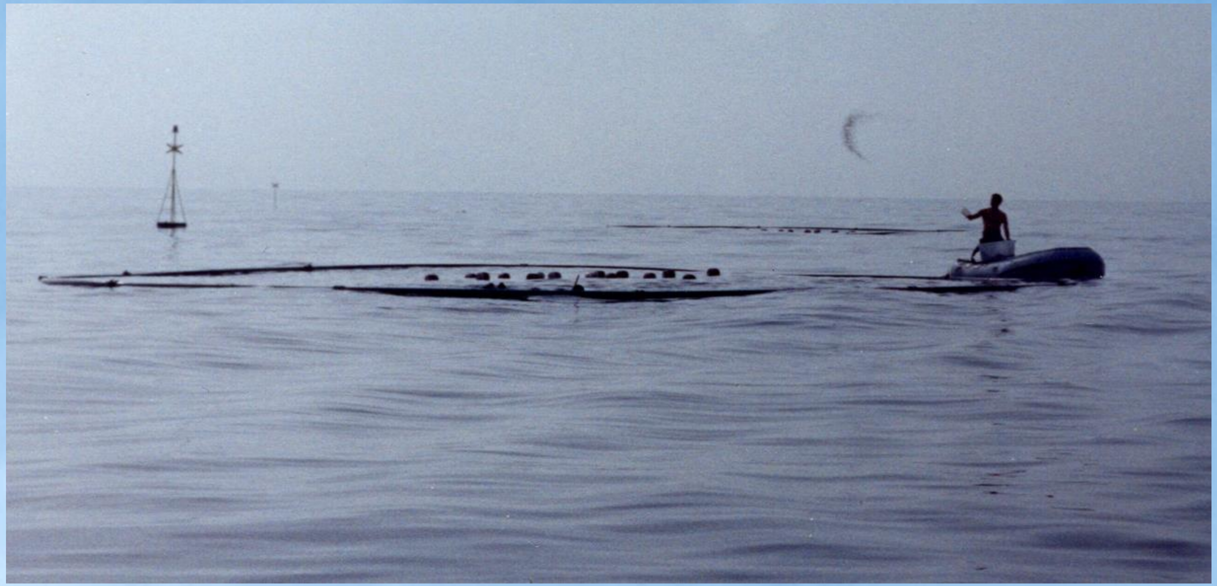
# 3. **<u>OPERATIONAL ASPECTS</u>**

## 3.2 Feeding the fish



Manually,

Or with portable cannon blower

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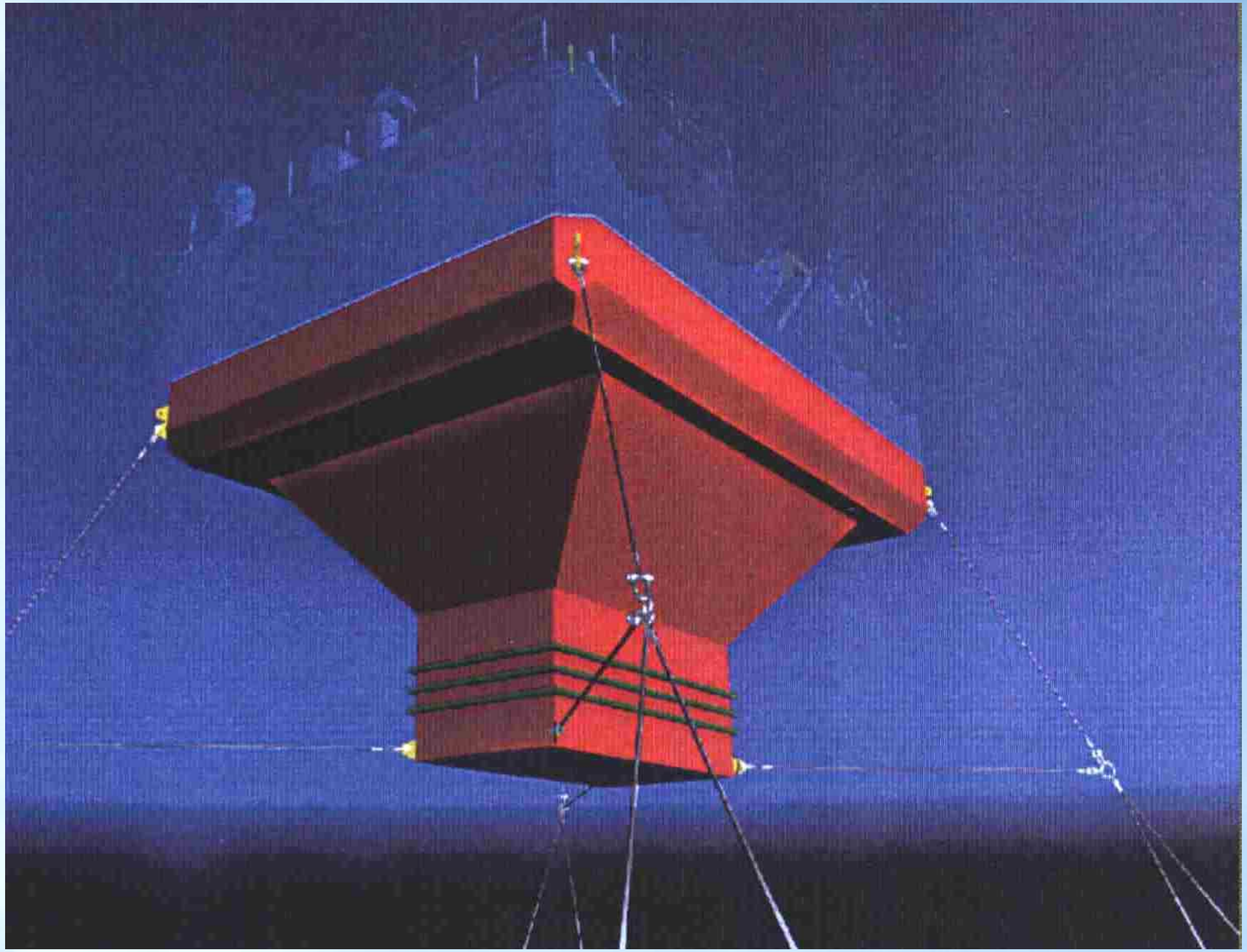
# 3. **OPERATIONAL ASPECTS**

## 3.2 Feeding the fish

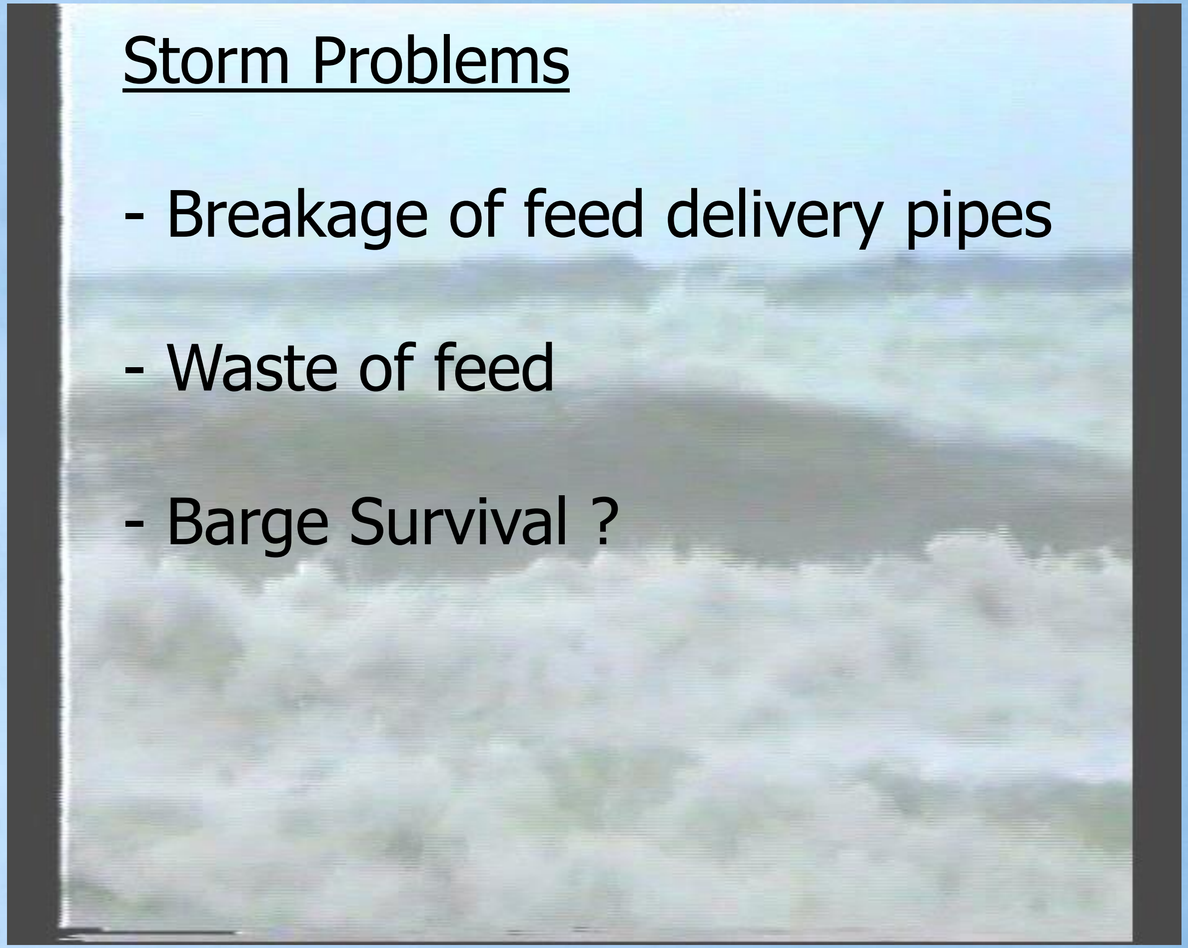
With 80 ton Cone Barge

# 3. OPERATIONAL ASPECTS

## 3.2 Feeding the fish with Barges



Cone Barge



# 3. OPERATIONAL ASPECTS

## 3.2 Feeding the fish

With small "Feed Buoy"

# 3. OPERATIONAL ASPECTS

## 3.2 Feeding the fish

With Offshore Feed Boat

# 3. OPERATIONAL ASPECTS

## 3.2 Feeding the fish

With Feed Boat

# 3. **OPERATIONAL ASPECTS**

## 3.3 Inspection and Maintenance

Strict Protocols need to be implemented to ensure integrity of all components, and fine-tuning of the cage system.

Nothing must be left for tomorrow:
small details may lead to big losses.

Inspection protocols are customised
for the equipment used and specifics of the site.

Control of Biofouling in relation to water flow
and interaction with the nets.

Sub-aqua control with divers is essential.

# 3. OPERATIONAL ASPECTS

## 3.4 Fish Harvesting Strategies

Regular harvesting to ensure continuous market supply is often a difficulty with open-sea farms.

A. Meteo conditions may prohibit sailing out of harbour and access to the farm.

B. Cage Geometry often limits use of standard harvesting techniques, particularly with submerged cages.

# 3. **OPERATIONAL ASPECTS**

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## 3.4 Fish Harvesting Strategies

Batch harvest of one whole cage in 1 to a few days would be ideal.

This is standard in the Salmon industry, but bass & bream farmers mostly need to supply fresh fish 2 x /week.

Offshore farms sited near to bays or ports can tow the cages to shelter area, and harvest gradually regardless of weather.

Distinct farm production units can be located at sites with opposite exposure conditions, allowing alternate harvesting.

With increasing scale of the industry, we may be able to cage batch harvest soon.

*…. unless individual cage volumes rise too.*

# 3. OPERATIONAL ASPECTS

## 3.4 Fish Harvesting Strategies

With TLC cages, various solutions are employed by different farmers.

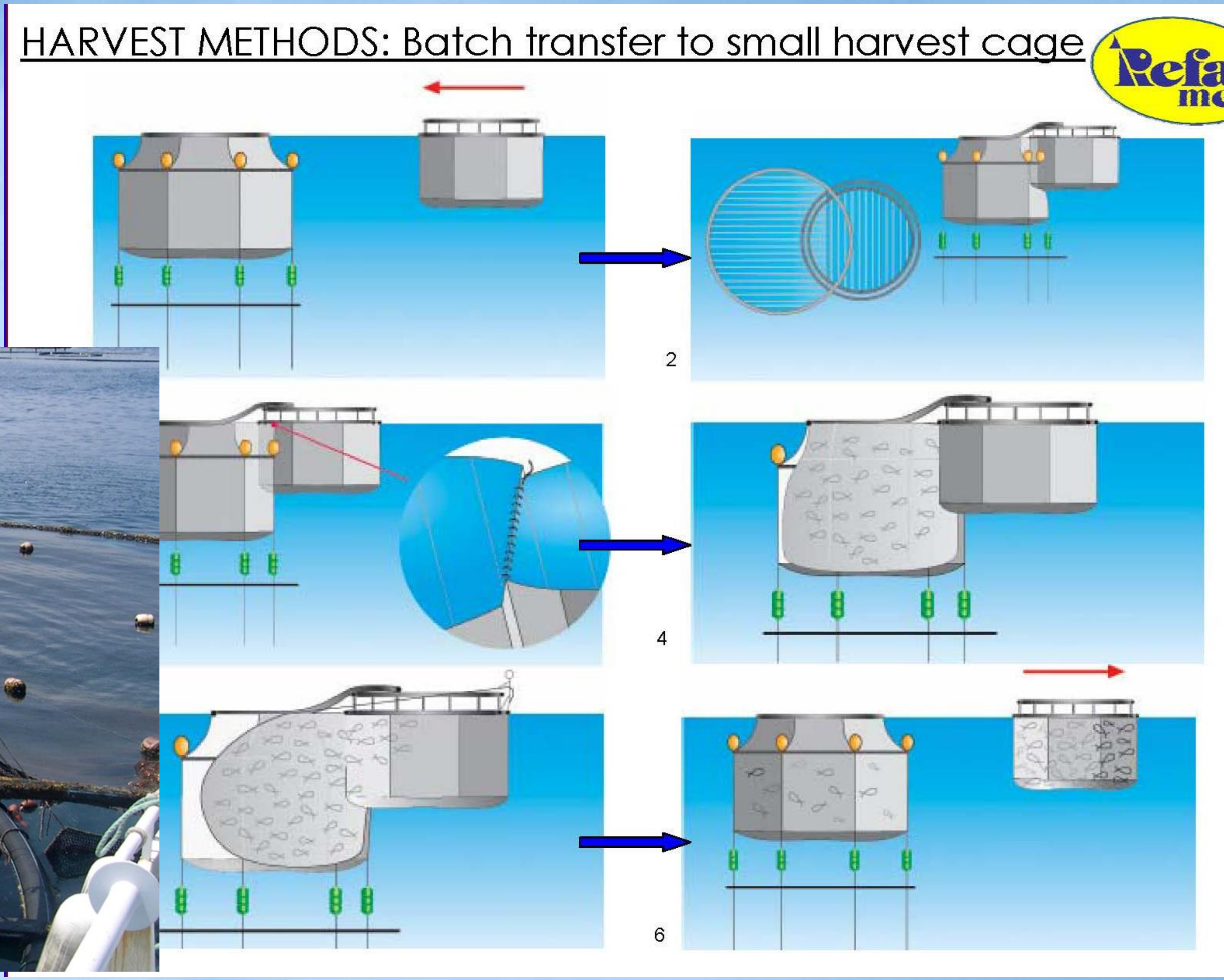
Direct harvest from the TLC grow cage may be used for small quantities.

Else, raise the grow cage-net and attach to a conventional floating frame;
remove the top-cover net, transforming it into a normal surface cage for subsequent harvest purpose.

# 3. OPERATIONAL ASPECTS

## 3.4 Fish Harvesting Strategies

Transfer lots of about 15 tons fish from grow cage to small, 10-m, harvest cage.



# 3. OPERATIONAL ASPECTS

## 3.4 Fish Harvesting Strategies

Transfer lots of about 15 tons fish from grow cage to small, 10-m, harvest cage.

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# 3. OPERATIONAL ASPECTS

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## 3.4 Fish Harvesting Strategies

Transfer lots of about 15 tons fish from grow cage to small, 10-m, harvest cage.

Advantages:

Remaining >50 t fish continue to grow.

Ease of harvest, even with rough sea.

## 4. **WHERE ARE WE TODAY ?**

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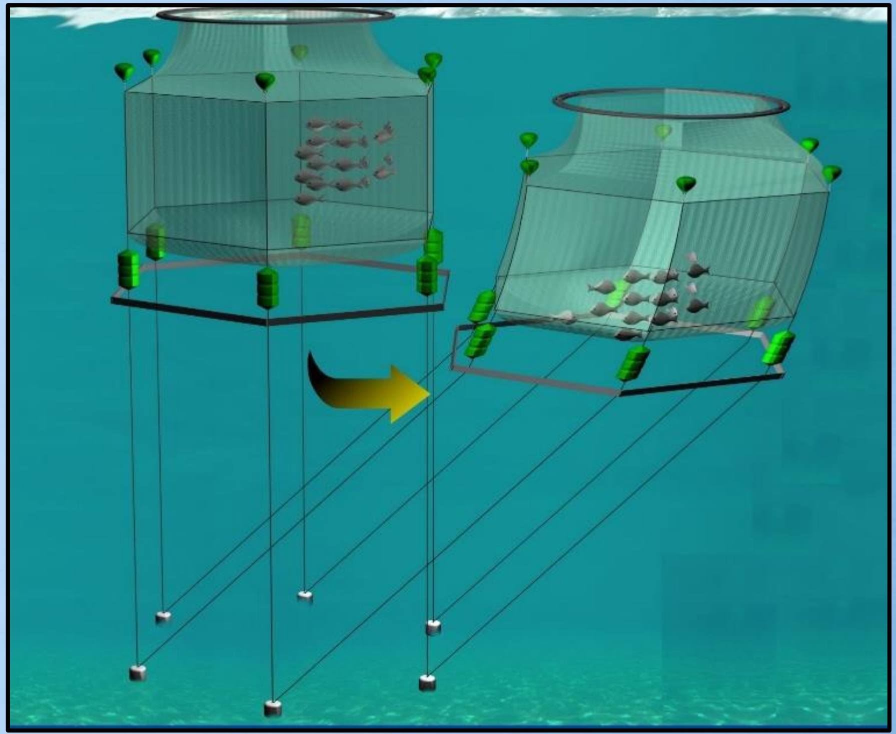
4.1 Many of the initial open-sea cage designs failed within few years in exploitation (technical &/or economical under-performance).

4.2 Floating PE cage systems, when specifically designed and maintained, have greatly improved their ability to resist waves and particularly currents.

They are still unable to sail 10 m waves though.

4.3 Of the pioneers from 25 years ago, it is only the submersible Sea Station, and the Tension Leg which survive in the open seas.

Neither are surface–based cage systems.



# 4. **WHERE ARE WE TODAY ?**

4.4 New project designs are being tested, such as the OceanFarm mega platform in Norway, and the development of large submersible cages.


4.5 Surface – based cage systems are subject to the most violent forces.
To increase strength you end up increasing the resistance to marine forces:
can become a Vicious Circle.

4.6 Our approach is to avoid the extreme loads and to allow the cage to "flex" with the elements whilst maintaining integrity of the system and the fish, rather than try to confront nature with brute force.

## 4. **WHERE ARE WE TODAY ?**

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4.6 Our approach is to avoid the extreme loads and to allow the cage to "flex" with the elements whilst maintaining integrity of the system and the fish, rather than try to confront nature with brute force.

4.7 Off the Israel coast our TLC cages have sailed through storms with 13 m high waves in 2013.

Main Scope: to implement affordable open-sea projects suitable also for medium and small scale farmers.

Thank you !

**Darko Lisac** *www.refamed.com*