

Ecological Risks of Net Pen Aquaculture in North American and African Great Lakes: Can BMPs be shared

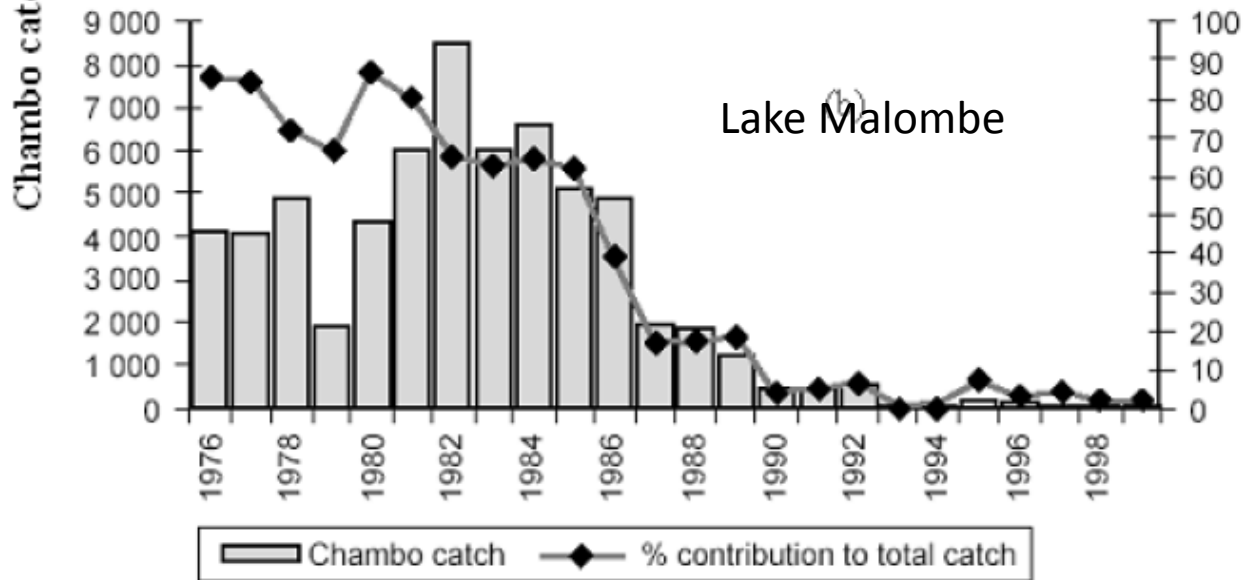
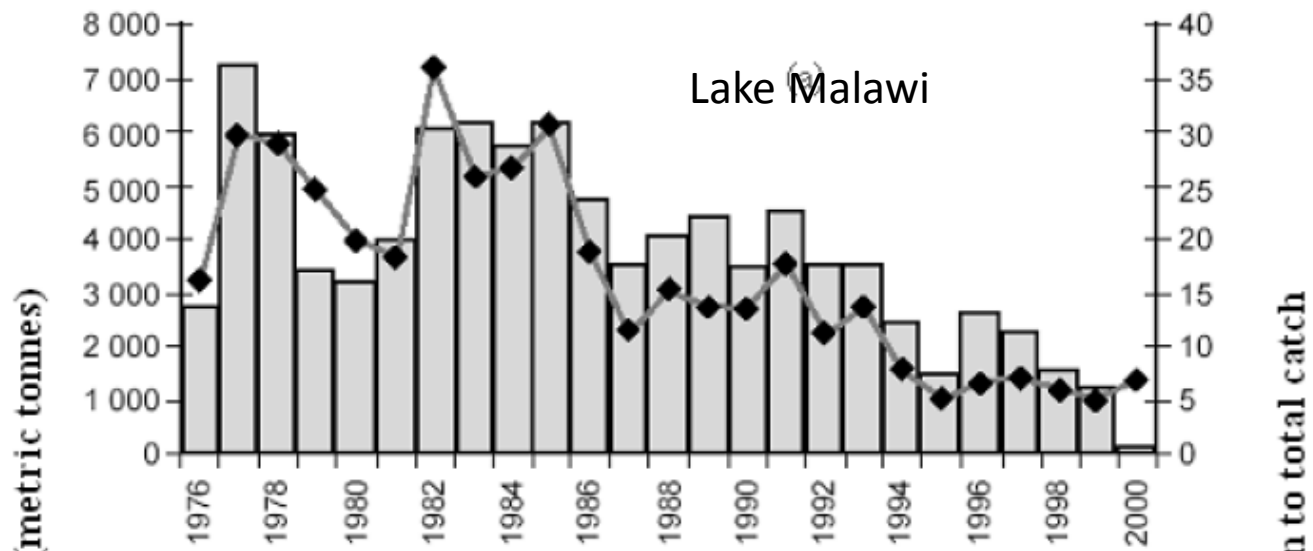
R.E. Hecky, J.M. Dettmers, M.J.G.S. Gondwe,
M. Macuiane, M. Ngochera



Lake Huron, Ontario



Lake Malawi/Niassa



Chambo (endemic tilapiines) catches in Lake Malawi and Lake Malombe. Data Source: Banda 2005

Great Lakes

Net-Pen Commercial Aquaculture:

A Short Summary of the Science



Eric J. Anderson, NOAA, Great Lakes Environmental Research Laboratory, John M. Dettmers, Great Lakes Fishery Commission, James S. Diana, University of Michigan, Sea Grant, Keith McCormack, Hubbell, Roth & Clark, James A. Morris, NOAA, National Ocean Service, A. David Scarfe, Aquatic Veterinary Associates LLC, USDA-APHIS-VS, Craig Stow, NOAA, Great Lakes Environmental Research Laboratory, Roy A. Stein, Chair, The Ohio State University

Recommended BMPs if aquaculture were

**Nine Generic BMPs
recommended for commercial
cage aquaculture in Lake
Michigan (North American
Great Lakes)**

**Net pen farm in Lake Malawi
offers opportunity to evaluate
their efficacy for global great
lakes**

BMP 1) Adopt adaptive management (AM) from beginning

Maldeco Fisheries which was granted a permit to initiate cage aquaculture in Lake Malawi

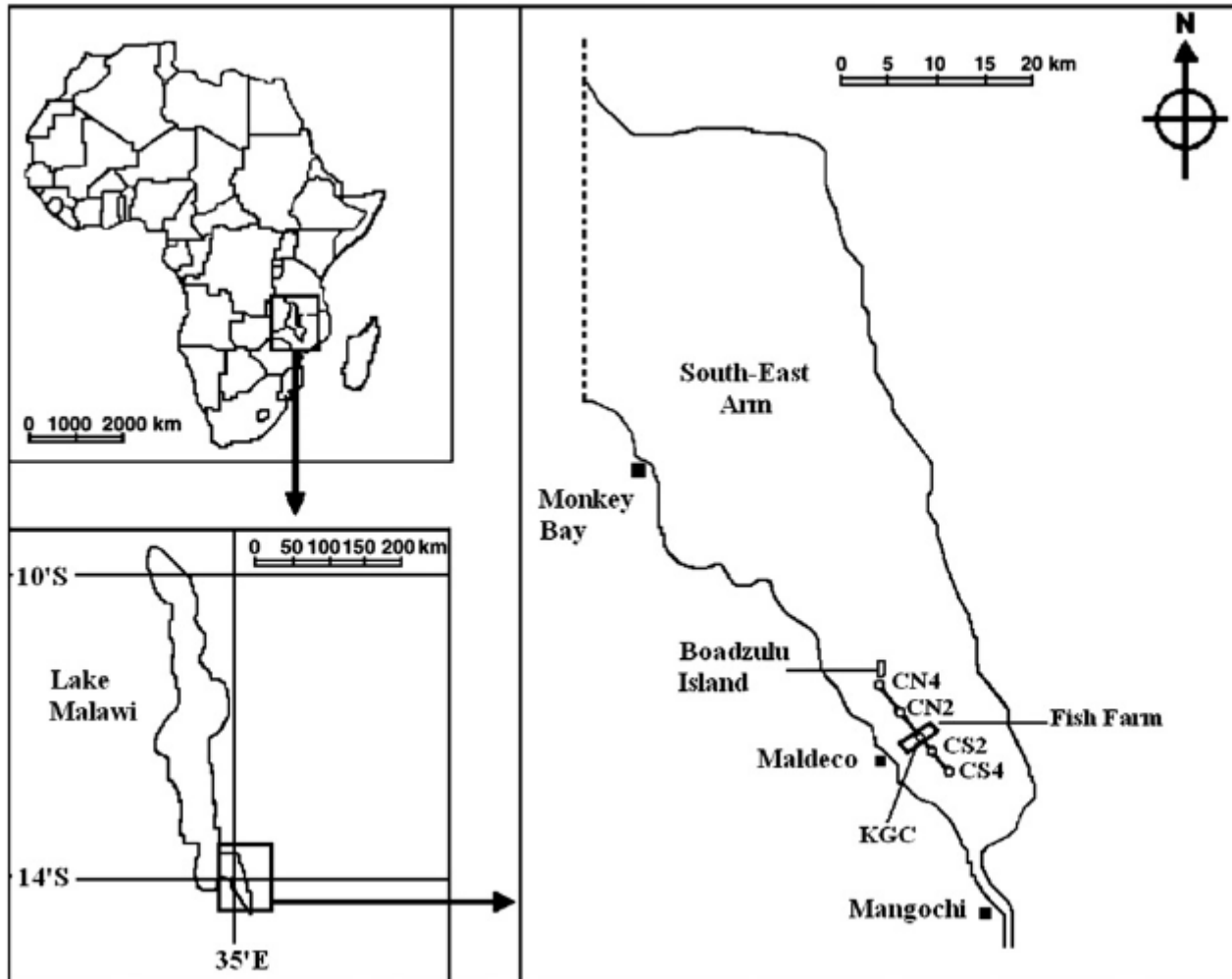
- 1) Objectives: 1) reduce pressure on wild stocks, 2) address high market demand, 3) rehabilitation of wild tilapiine fishes**
- 2) Design submitted and approved as a prototype
- 3) Lessons learned would inform a policy for net pen aquaculture**
- 4) No further aquaculture farms until Maldeco experience evaluated**

 **The approach taken by government was consistent with AM**

BMP 2) Apply Before-After-Control- Impact (BACI) as experimental design

- a) Malawi Fisheries conducted fisheries and water quality monitoring near installation and at remote sites prior to operation and continued
- b) Graduate students from University of Waterloo (2006-2008) and University of Minnesota –Duluth (2012) conducted water quality and fisheries investigations at the farm site and at control sites
- c) Graduate studies allowed closer examination of several risks identified with aquaculture experience in other parts of the world


 **BACI design was followed for fish community studies by Malawi Fisheries and partially followed by graduate studies (no pre-development studies at the site)**

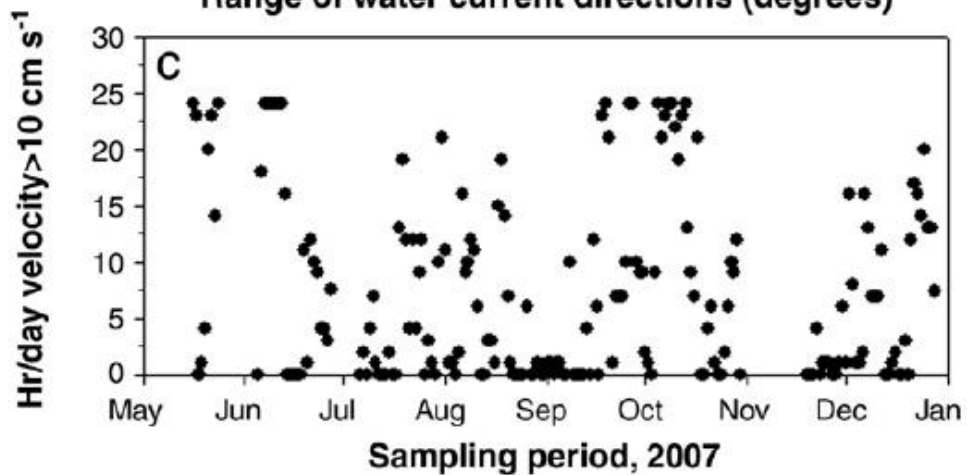
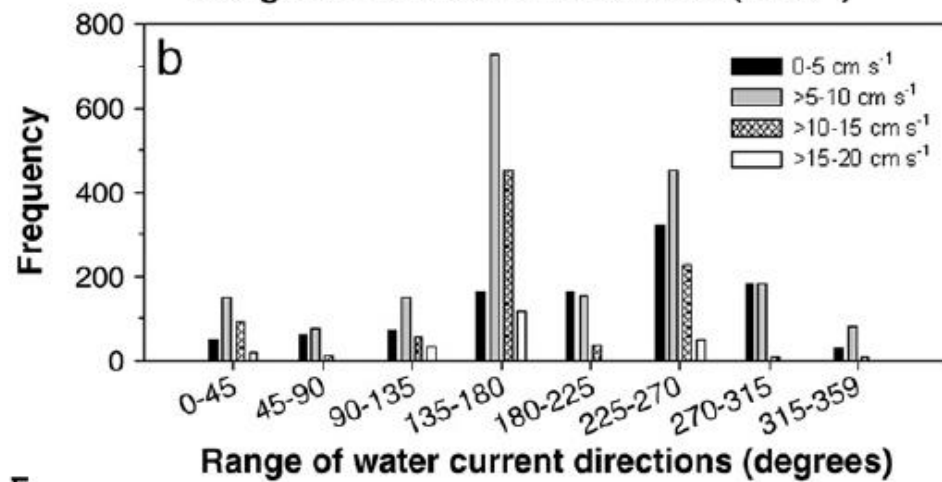
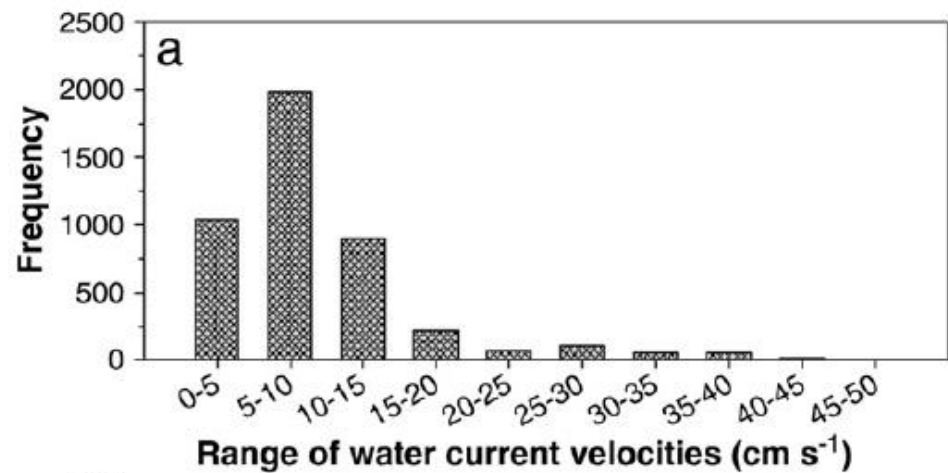


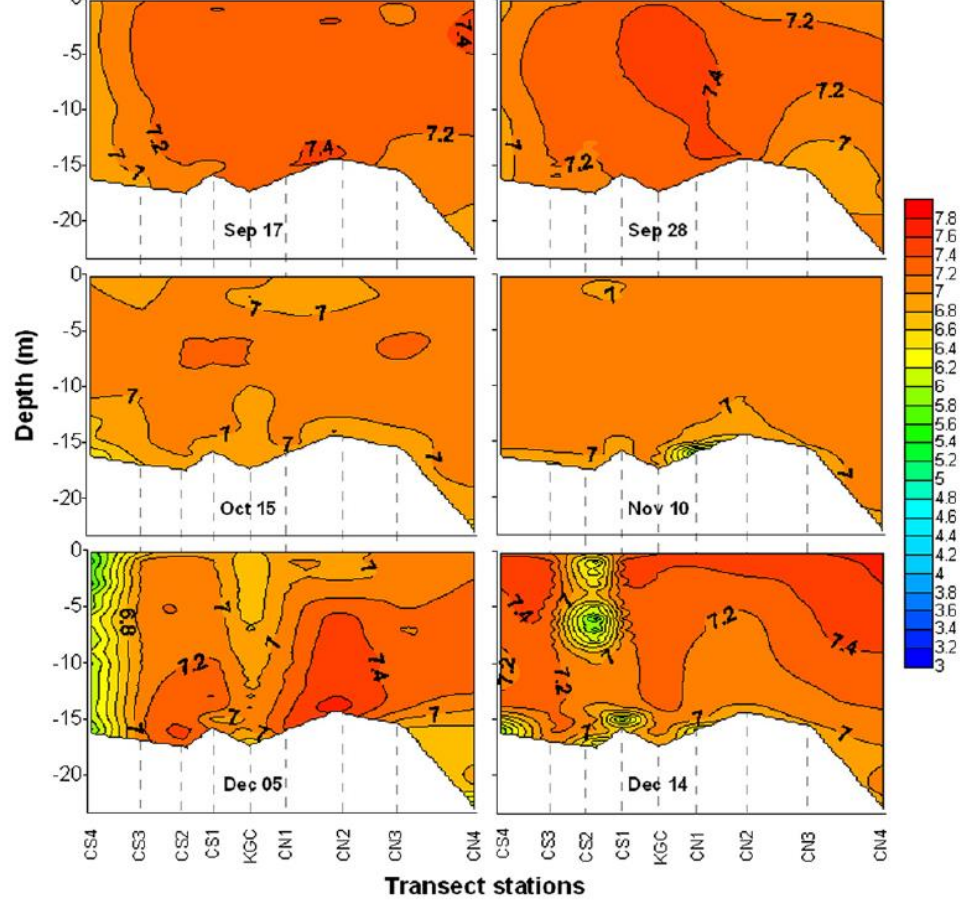
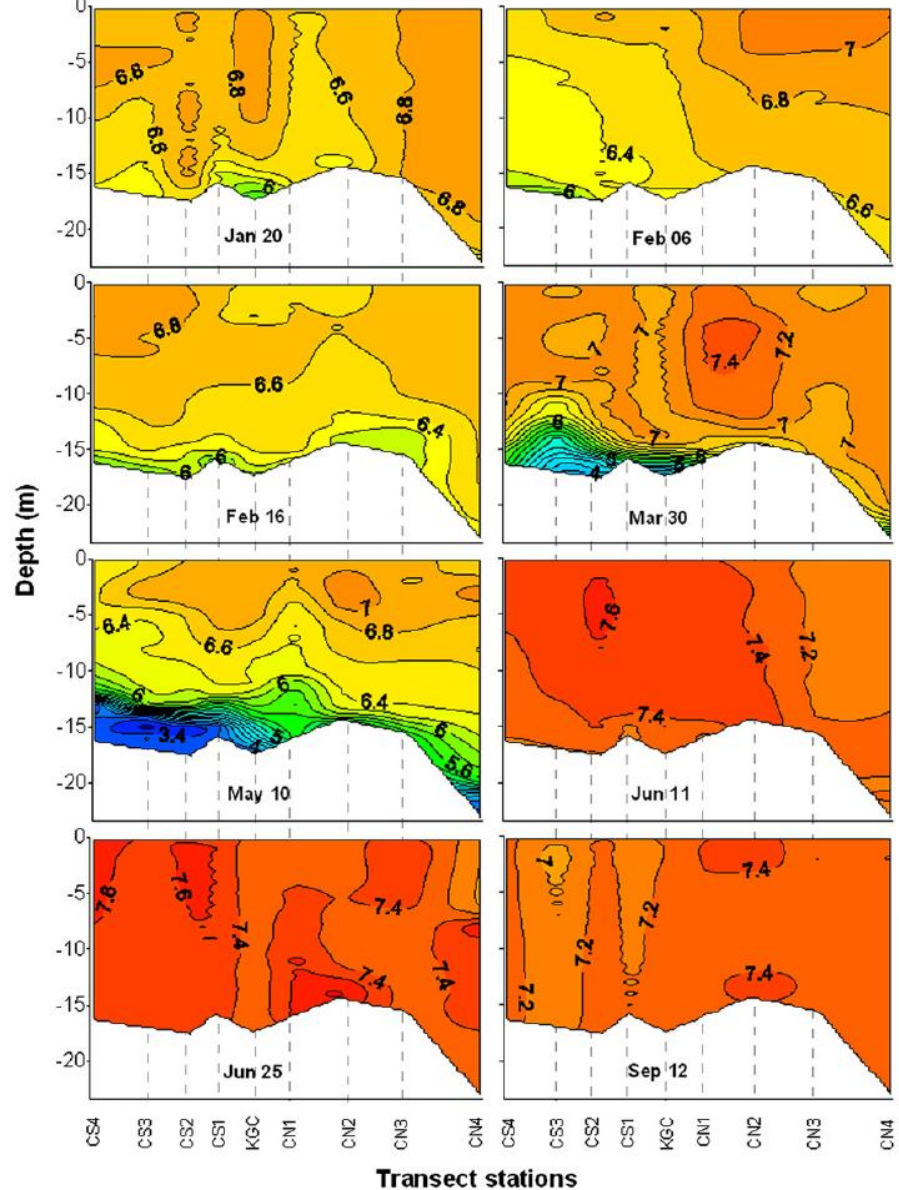
Gondwe et al . 2012.
Aquaculture

BMP 3) Siting : adequate flushing to insure cages well oxygenated with good quality water; avoid sensitive environments and habitats for aquatic organisms

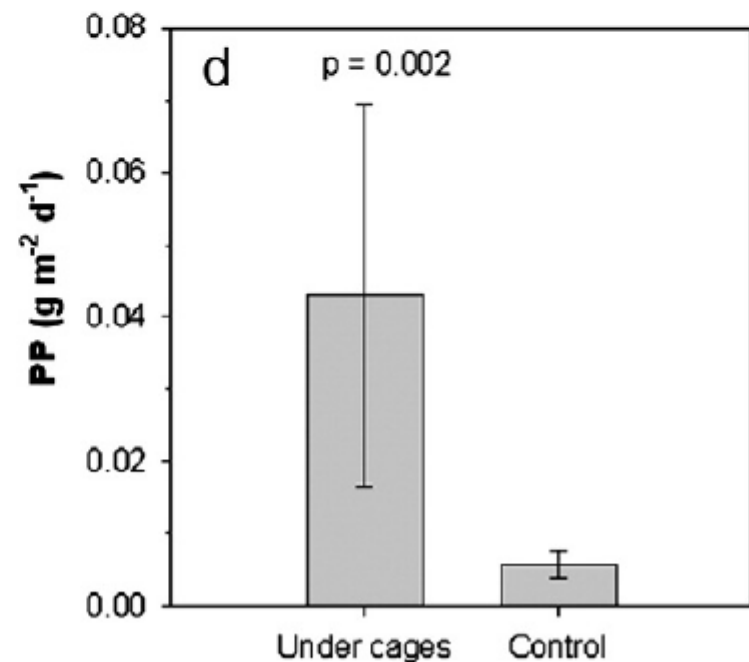
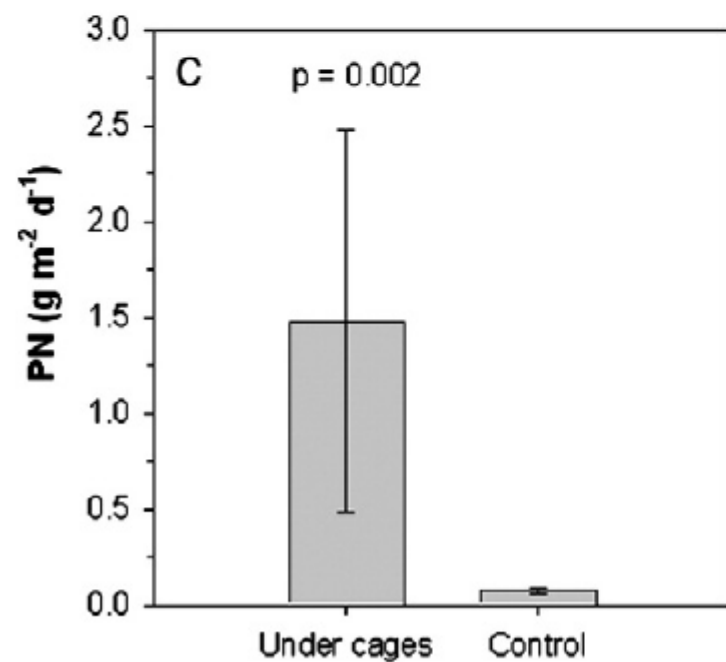
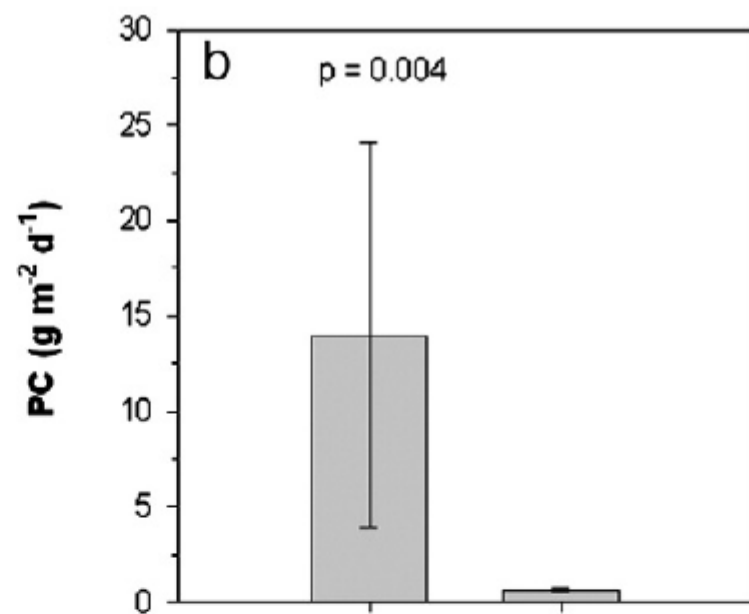
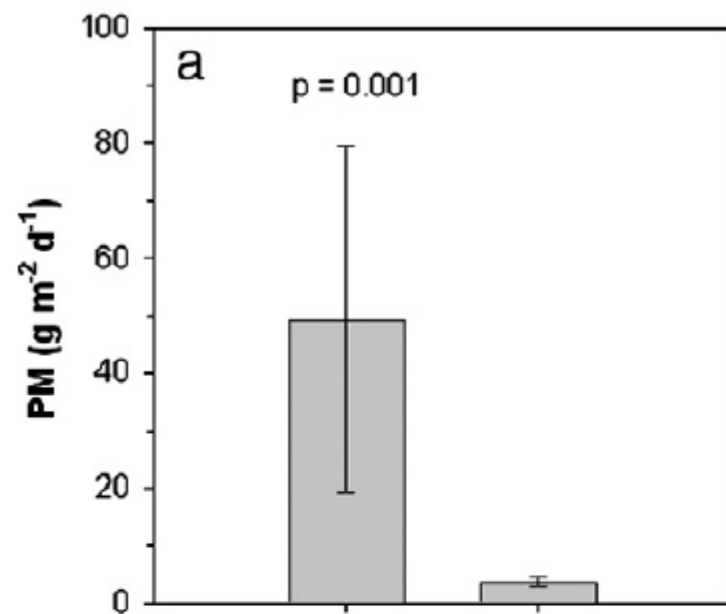
- a) Up to 51 cages , 16 m dia. 6 m depth deployed along open coast line one km offshore in 12-22 m water depth over fine sand
- b) Active flushing of cages: persistent long shore currents ave. 10 cm s^{-1}
- c) Oxygen concentrations maintained at levels characteristic of coastal environment with no evidence of impact No detectable impact on water quality
- d) Little evidence of strong impact on sediment quality
- e) Stocking rates of fish were well within O^2 carrying

 **Siting was conducive to maintaining good water quality and oxygenation within the farm as well as away from the farm**





Farm site well oxygenated year-round; some lower oxygen on bottom at end of stratified season at both farm site (KGC) and control sites



Sampling sites

BMP 4) Culture native species to reduce risk of introducing exotics and to minimize ecological and genetic impact of escapement

- a) Two native fishes were selected and successfully cultured
- b) Original objective was to use part of cultured catches to restore natural stocks; planned escapement

 **BMP 4 has been realized; however , very limited release for restoration has been realized**


BMP 5) Maintain biosecurity protocols and monitoring to reduce risk of disease occurrence and transmission

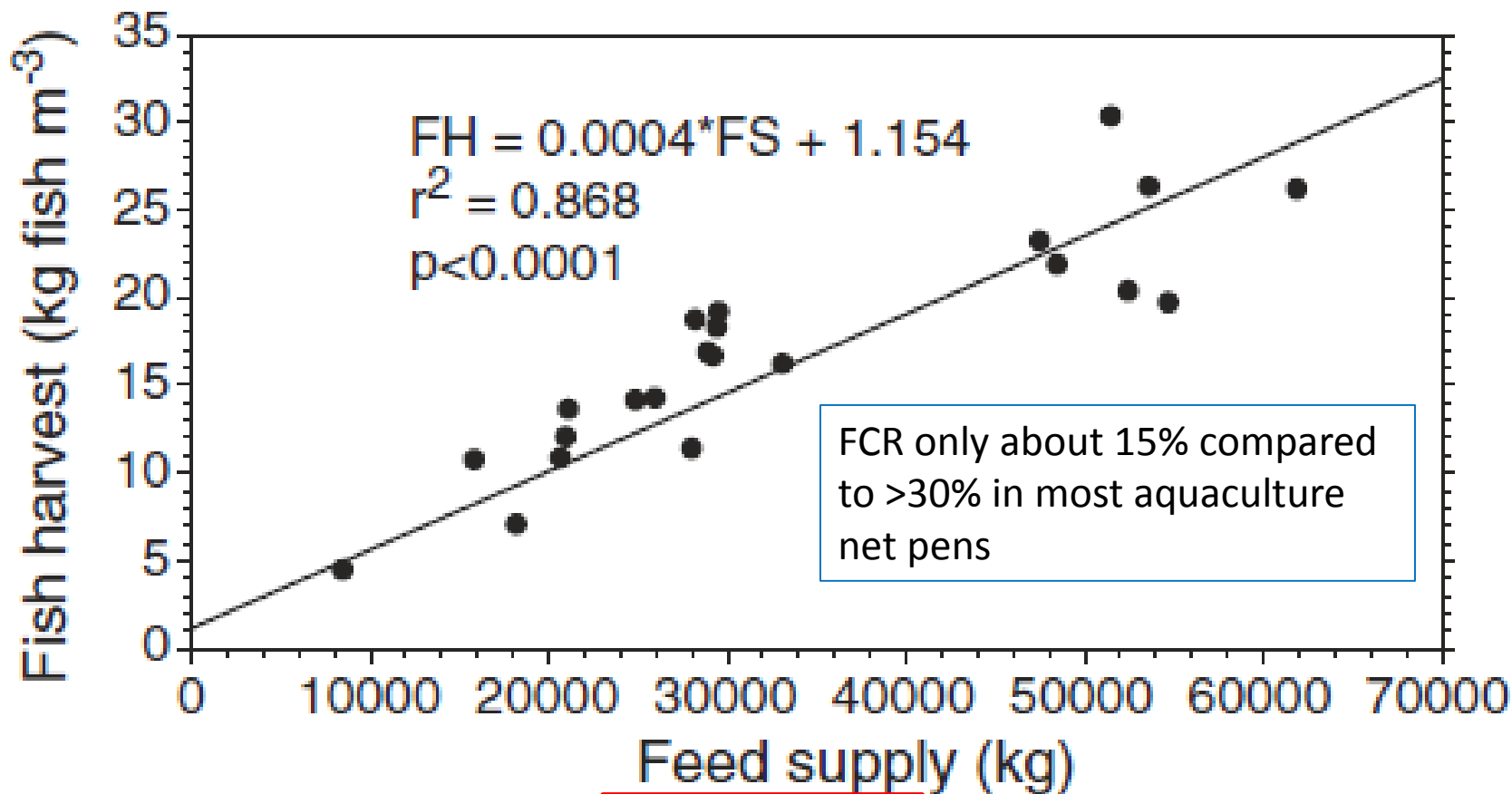
- a) No routine monitoring for fish diseases instituted
- b) Daily monitoring of fish mortality and monthly monitoring of growth has been realized to monitor fish health

 **Limited implementation of this BMP**

BMP 6) Vigorously pursue all available and possibly future practices to minimize net-pen effluents; maximize efficiency of feed utilization not just maximum growth; low Phosphorus<1% in feed recommended

- a) Low P (<1%) feeds utilized but N content was relatively low ;
- b) Feed conversion ratio (FCR) was low and variable; possibly due to low N content in feed
- c) Water quality in cage farms was not significantly impacted
- d) Lower than recommended feeding rates

 **This BMP was partially met. At realized scale of operation nutrient impacts were not significant on local receiving waters; however, studies advised that N:P of feed should match the N:P utilized by caged fish to improve FCR and reduce excess P loss from cages**

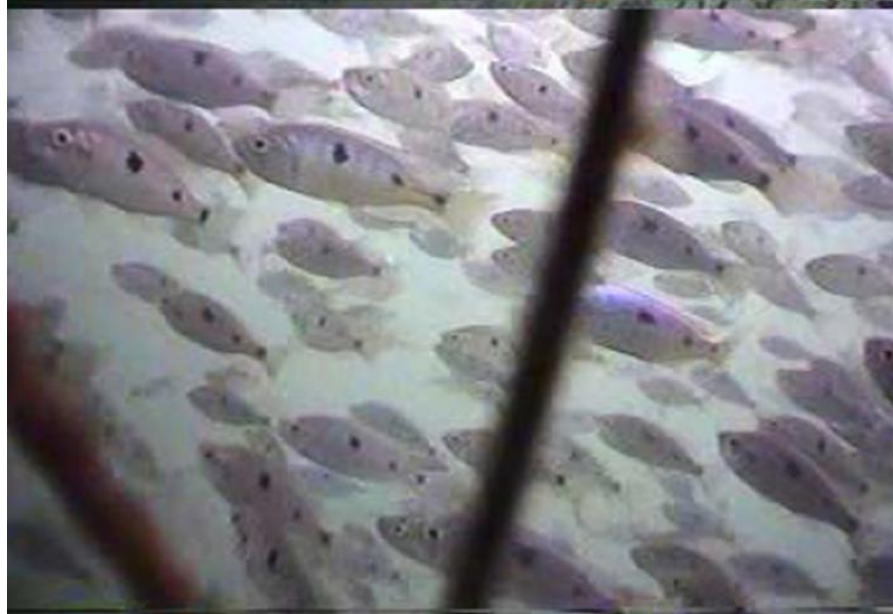
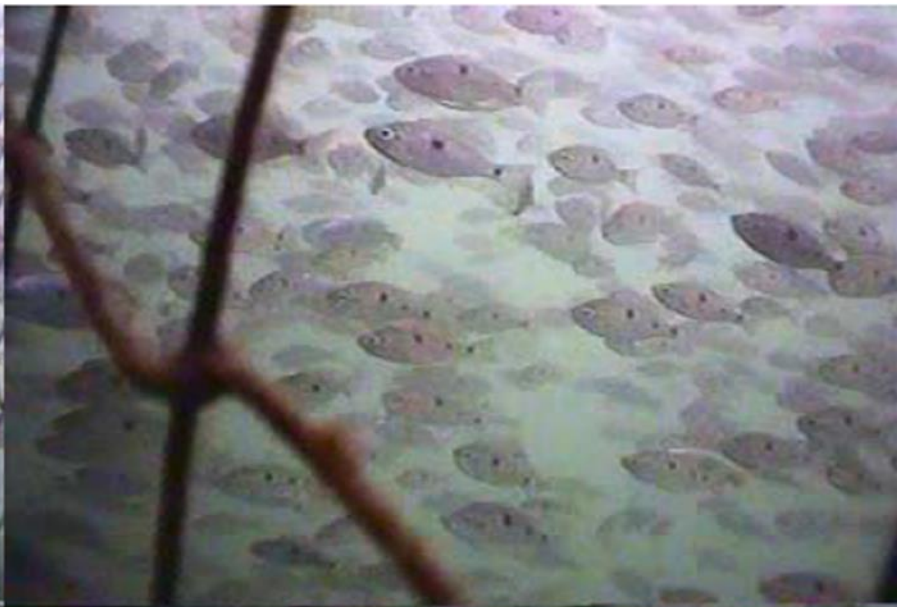


	% C	% N	% P	% H ₂ O
Feed	44.57 ± 2.63	5.75 ± 0.83	0.87 ± 0.11	5.20 ± 0.22
Fish	49.17 ± 1.96	13.96 ± 0.76	0.81 ± 0.16	69.00 ± 2.36

BMP 7) Management plan for wild fishes within boundaries of farm

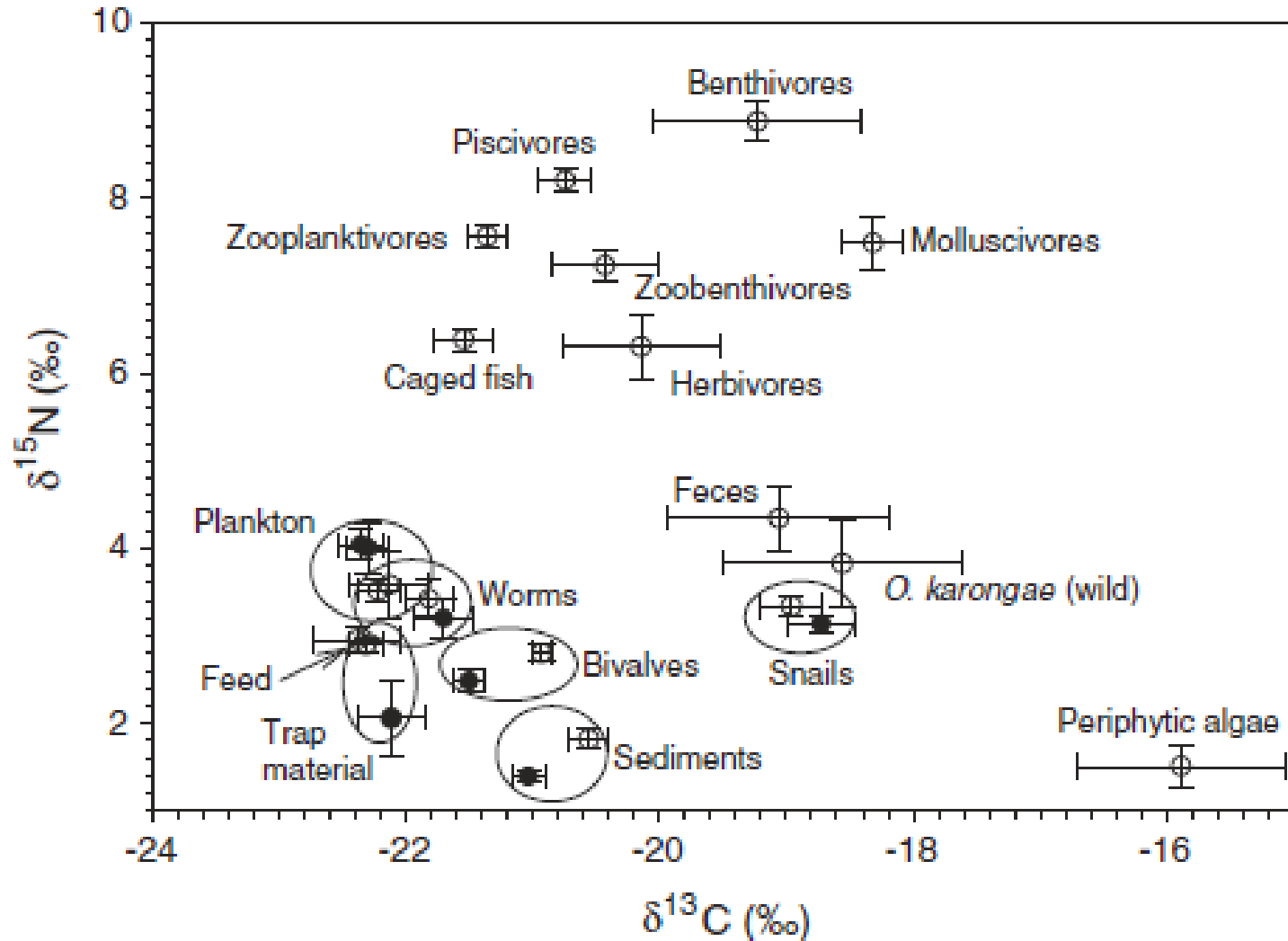
- a) Farms in public waters but require restricted access
- b) Net pens attracted wild fishes leading to conflict with fishers
- c) Studies confirmed the high densities of wild fish; little evidence that attracted fishes realized a nutritional benefit
- d) Important for future studies to evaluate if net pen operations provide a net benefit to wild fish populations and to wild fisheries
- e) No release of cultured tilapiines to the lake for restoration

✘ Maldeco permit was designed to have positive impact on wild tilapiine populations. No releases of caged fish to the wild; rather conflict arose over the attraction of wild fish into the exclusion zone

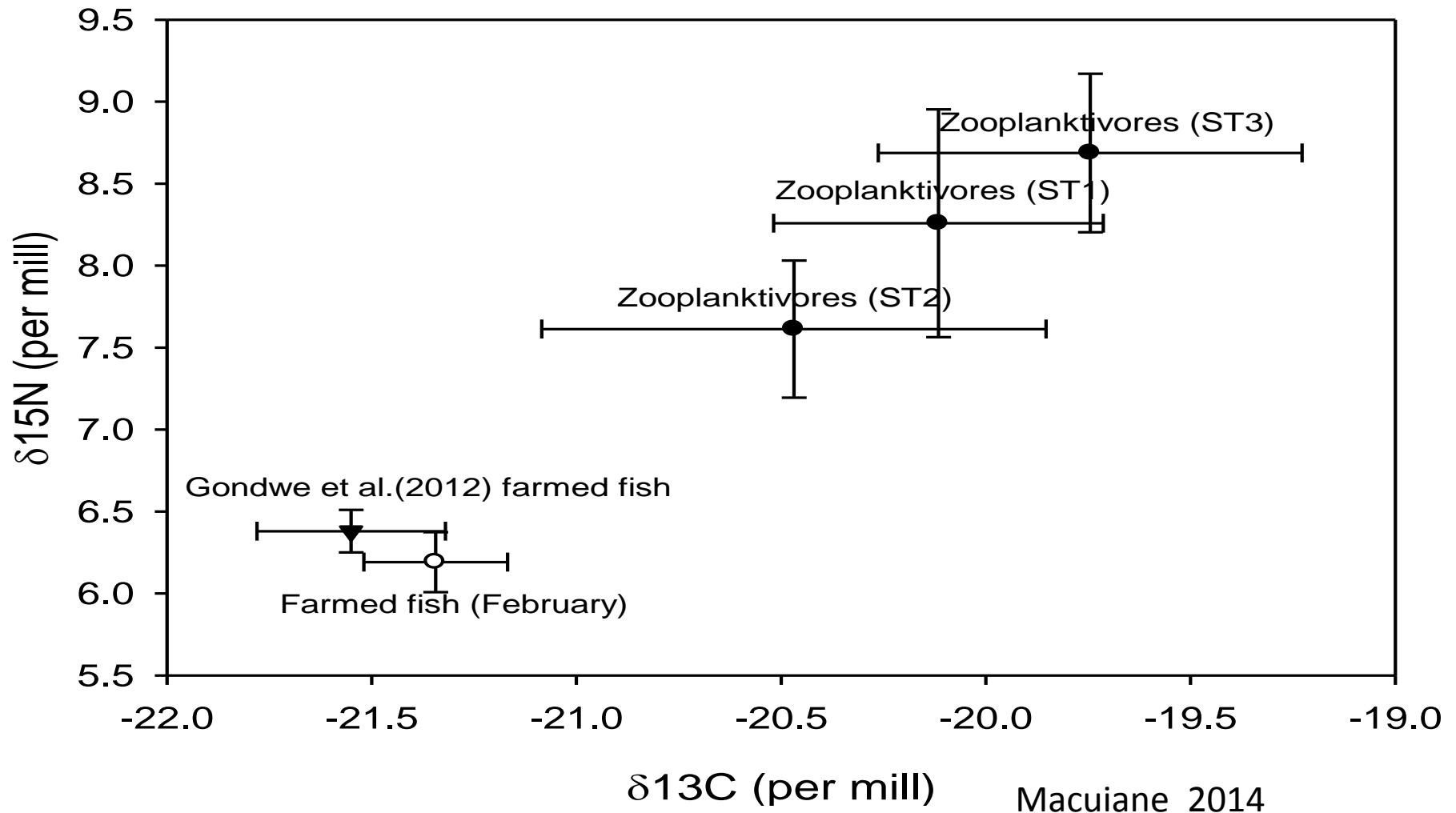




Stable isotopes can reflect food sources; wild fish in vicinity of cages were isotopically distinct from the caged fishes



Zooplanktivores were most abundant trophic group at the farm ; but they were not significantly different from control sites



BMP 8) Limit entry of new farms

- a) Substantial amounts of wastes discharged
- b) Individual facilities cumulatively can change lake concentration; five Maldeco (3000 T/y harvest increased to 15,000 T/y) would be the equivalent of nearly doubling the annual loading of dissolved P to Lake Malawi of largest rivers
- c) **Cumulative effects of farms with even insignificant effects on local concentrations must be considered and international consensus reached** on acceptable nutrient concentrations for lake and loadings to sustain high biodiversity lake



This BMP requires international collaboration and agreement to limit the entry of new farms to an agreed sustainable number

9) Developers should post bond to cover costs of decommissioning commercial farms

a) Maldeco farm is still operating although below design permit.

This BMP cannot be evaluated at present

Conclusions:

- 1) **BMPs were mostly followed** with no evidence of negative ecological impacts
- 2) Strongest impact on surrounding environment was dense aggregation of wild fish in the exclusion zone around the pens.
Requires formulation of specific policy to avoid conflicts.
- 3) Open net pen operations unavoidably result in discharge of large amounts of wastes, the **impact of added nutrients on the lake as a whole will increase in proportion to the number of farms and pens operating.**
- 4) **Riparian countries should adopt a common set of BMPs for commercial aquaculture and agree on the assimilation capacity of the lake to limit the cumulative impact of net pens.**