
Growth Performance of Pompano (*Trachinotus blochii*) Fed Fishmeal and Soy Based Diets in Offshore OCAT Ocean Cages

Results of the 2007 OCAT Cage Feeding Trial in Hainan, China

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ABSTRACT

An offshore ocean cage feeding trial was conducted by the American Soybean Association International Marketing (ASA-IM) program in southern Hainan Province, China, in 2007 to compare pompano performance with feeds having standard and low fishmeal inclusion rates. The trial compared pompano growth and feed conversion efficiency with the standard ASA-IM 43/12 pompano growout diet, in which 45% of the protein was supplied by fishmeal, and a nutritionally equivalent diet in which dehulled soybean meal and soy protein concentrate were the major protein contributors, and in which fishmeal supplied only 16% of the protein. Pompano were cultured in 100-m³ OCAT submersible offshore ocean cages at an average density of approximately 9,600 fish per cage.

There was no difference in pompano performance with the two feeds. Pompano in two OCAT cages fed the ASA-IM 43/12 standard feed grew from approximately 19 g to 608 g in 146 days with >99% survival. Pompano in two OCAT cages fed the 43/12 soy feed grew from approximately 26 g to 610 g in 146 days with >99% survival. Average feed conversion rates for the 43/12 standard and 43/12 soy feeds were 2.51:1 and 2.59:1, respectively. High pompano survival was attributed to new fish health management protocols and pathogen treatment regimes adopted in the 2007 trial.

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INTRODUCTION

The American Soybean Association International Marketing (ASA-IM) has conducted offshore ocean cage feeding trials with goldenfin pompano (*Trachinotus blochii*) in Hainan, China since 2004 in cooperation with Mr. Liang Xinxiu of Lingshui #601 marine cage farm. The trials have been conducted in 100-m³ prototype offshore ocean cages. The prototype cages were commissioned by the United Soybean Board under the Ocean Cage Aquaculture Technology (OCAT) component of the Managed Aquaculture Program. Cage design was based on criteria and recommendations provided by a team of American Soybean Association International Marketing aquaculture specialists. The OCAT cage has a rigid HDPE cage frame in the shape of a truncated pyramid, with a 100-m³ volume fish culture net suspended inside the cage frame (Figure 1). The cage uses a single point mooring and is designed to self-submerge with increasing hydrostatic pressure from increasing water current velocity. Details of the cage design and construction are available in CD form from the U.S. Soybean Export Council (reference OCAT Engineering Manual).⁶

Feeding trials conducted by ASA-IM from 2004 to 2006 in the OCAT cages evaluated the OCAT cage design and performance under normal to typhoon storm conditions, tested and demonstrated the use of extruded floating feeds for culturing pompano, and tested culture techniques for pompano in offshore cages. Cage performance, including automatic submersion, extruded feeds, and tested culture techniques were all found to be satisfactory for the Lingshui Bay location. The environment in nearby Xincun Bay, however, where the pompano hatcheries are located and most fingerling production occurs, were found to be highly polluted and the source of significant fish pathogens. Fish pathogens transferred from Xincun Bay to the offshore cage trial site resulted in seasonal disease outbreaks and periodic high fish mortality levels. As a result, ASA-IM expanded its fish disease diagnostic and treatment efforts in 2007 through the assistance of a fish pathology specialist from Louisiana State University.

TRIAL METHODOLOGY

A three-stage production regime was adopted for the 2007 OCAT cage feeding trial. In stage one, pompano juveniles purchased by the trial cooperator from a local hatchery were cultured in net cages suspended from a floating wooden frame raft at the cooperator's cage farm site inside Xincun Bay, Hainan, China. Juvenile goldenfin pompano were cultured from approximately 5 g in size to 25 g with the ASA-IM 47/15 marine fingerling feed (47% protein and 15% fat) during this stage (Table 1). Fish were fed the 47/15 feed to satiation three times daily. All feed was fed in extruded, floating pellet form. When the pompano reached approximately 25 g in size, they were graded, restocked in net cages suspended from a wooden cage raft frame, and onward cultured with one of two growout diets.

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Stage two was a departure from the normal practice of culturing fingerlings to 70-100 g inside Xincun Bay, and consisted of offshore fingerling production from approximately 40 g to ≥ 70 g in net cages suspended from a wooden cage raft frame anchored near the offshore OCAT cage site approximately 4 km offshore of Hainan Island. Stage two was adopted in 2007 due to increasing levels of pollution and fish disease occurrence inside Xincun Bay. Stage two began with weaning of the pompano from the 47/15 fingerling feed to one of two test feeds for growout to market size when the pompano reached an average size of approximately 25 g. The two test feeds were the ASA-IM 43/12 standard marine growout feed (43/12 STD), and a 43/12 feed formulated with the majority of protein derived from soy products (43/12 SPC). The 43/12 standard diet has been tested and developed by ASA-IM over several years in China, and is typically formulated with approximately equal parts dehulled soybean meal and fish meal (Table 2). In 2007, the fishmeal and dehulled soybean meal inclusion rates in the 43/12 STD feed were both 30%, with fishmeal contributing 45% of total protein in the diet. The 43/12 SPC feed is a nutritionally equivalent feed to the 43/12 STD feed, but the majority of protein is contributed by a combination of dehulled soybean meal (48% crude protein) and animal grade soy protein concentrate (65% crude protein) (Table 3). For the 2007 trial, the fishmeal inclusion rate in the 43/12 SPC feed was 11%, with fishmeal contributing approximately 16% of total protein to the diet. Inclusion rates of dehulled soybean meal and soy protein concentrate in the 43/12 SPC feed were 24% and 21.3%, respectively. Equal numbers of pompano were fed one of these two diets from an average fish size of approximately 25 g to ≥ 70 g in size during stage two. Both feeds were fed in extruded, floating pellet form. Pellet size was increased as the fish grew, with pellet size maintained at approximately 50% of the open mouth size of the pompano.

Stage three consisted of the culture of pompano from an average size of approximately 75 g to a target market size of 600 g in four, 100-m³ OCAT cages located 4 km offshore in southern Hainan Province, China. Pompano were stocked in the four OCAT cages at an average density of approximately 9,600 fish per cage. Pompano in two of the OCAT cages were fed the 43/12 STD feed. Pompano in the other two OCAT cages were fed the 43/12 SPC feed. Fish in both cages of each feed treatment were fed identically at each feeding. Fish were fed using the 90% satiation technique, with the 100% satiation level re-established on the same day each week. Some variation in feeding level occurred due to weather.

Pompano were sampled once monthly to estimate growth. Feed input, fish feeding response, water temperature and wind and weather conditions were recorded daily over the course of the trial. All feeds and key feed ingredients were tested for compliance to specifications. Soy protein concentrate 65 used in the 43/12 SPC feed was obtained from the ADM manufacturing plant in China, and is marketed under the trade name Soycomil.

FISH DISEASE MANAGEMENT

Significant disease outbreaks and pompano losses occurred in the ASA-IM OCAT trials conducted in 2004, 2005 and 2006. Cooperation with a fish disease laboratory in China

for pathogen diagnostics and treatment recommendations was only partially successful in resolving the disease issues, so the OCAT project obtained the additional services of a fish pathology specialist from Louisiana State University, Dr. John Hawke, in 2007. During two visits to the OCAT site, Dr. Hawke identified and assessed pathogens impacting cultured pompano and other marine fish species within and outside Xincun Bay, Hainan, and identified appropriate treatment regimens for identified pathogens. Treatments were required during the OCAT feeding trial for both parasitic and bacterial pathogens. Identified pathogens and treatment regimes are reported in the results section.

TRIAL RESULTS

Pompano Performance

The majority of pompano cultured in stage one with the 47/15 marine fingerling feed grew from an average of 6 g to approximately 25 g in 29 days (Table 4; Figure 2). Average FCR with the 47/15 feed for three of the four groups of pompano fingerlings, representing 80,000 fish, was 0.98:1. FCR for the smallest of the four groups of fingerlings, representing 20,000 fish, was 1.86:1.

There was no difference in fish performance for pompano fed the two 43/12 growout diets. Pompano in two OCAT cages fed the 43/12 STD feed grew from an average weight of 19 g to an average harvest weight of 608 g in 146 days (Table 5). Pompano in the two OCAT cages fed the 43/12 SPC feed grew from an average weight of 26 g to 610 g in 146 days. Average fish survival in all four cages exceeded 99%. Average FCR with the 43/12 STD feed was 2.51:1. Average FCR with the 43/12 SPC feed was 2.59:1. Pompano in all four cages had excellent coloration and body form at harvest.

Pathogen Diagnosis and Treatment

Pompano were sampled for disease pathogens throughout the trial, beginning with stage one fingerling production inside Xincun Bay. Pathogen evaluations conducted in mid June indicated the trial pompano fingerlings were heavily infested with a variety of ectoparasites, including *Paratrichodina obliqua*, *Trichodina sp.*, and *Cryptocaryon irritans*. *Paratrichodina* comprised the largest concentration of parasites, and impacted primarily the gills. In addition, *Streptococcus sp. agalactiae* bacteria were identified in pompano fingerlings exhibiting erratic swimming and emaciation. Identification was made by API Rapid Strep test kits (BioMerieux).

Pompano infected with gill and body ecto-parasites were treated with a 100-ppm formalin bath for one hour in large plastic cloth bags at the cooperators' cage farm inside Xincun Bay. Heavy aeration was supplied during treatment, and oxygen was maintained on standby in case the fish became excessively stressed. Formalin bath treatments for parasite control were required at 14-day intervals while the pompano remained in Xincun Bay. Subsequent testing revealed that the treatments were effective in controlling parasites but re-infestation occurred after 14 days.

The trial pompano were moved offshore on 10 July 2007. A final formalin bath treatment was applied to the fish on July 14 at the offshore site. A medicated feed treatment was applied in late July to control *Streptococcus sp. agalactiae*. Florfenicol was added to the two test feeds so that pompano were dosed at 20-mg florfenicol per kilogram of fish per day for 10 days. Pompano feeding response was aggressive at the time of the florfenicol feed treatment. Pompano were fed the medicated feed for five days in the offshore fingerling cages. The pompano were then transferred to the four OCAT cage and fed the medicated feed for an additional five days.

Cage Performance

One modification was made to the OCAT cages in 2007. The cage frames of all four OCAT cages were painted with boat anti-fouling paint to reduce the level of bio-fouling and subsequent annual frame cleaning. Use of the anti-fouling paint resulted in negligible bio-fouling of the cage frames, in comparison to heavy bio-fouling in the three previous years. Results with the bio-fouling paint are reported in detail in the OCAT Engineering Manual.

Net bio-fouling during the 2007 OCAT trial enclosed an estimated 5% of the open mesh area between fish stocking and harvest. As a result of the low bio-fouling level, no net changes were required during the 122-day period the pompano were in the OCAT cages.

Two typhoons of significant magnitude struck the OCAT trial site in 2007. Typhoon Lekima was the strongest, and was classified as a Force 10 storm on the Beaufort scale⁷. This typhoon impacted the OCAT cage site on October 2 for a period of twelve hours (Figure 3). A structural check of the OCAT cages after the typhoon found no damage to any of the four OCAT cages. There was a slight increase in fish mortality in the two weeks following the typhoon, but recorded fish mortalities averaged less than 17 fish per cage, and equated to less than 0.0018% of the total cage fish populations of approximately 38,400 fish. Results indicate the OCAT cages auto submerged during at least a portion of the storm, resulting in negligible storm impact on the cages and minimal storm impact on the cultured pompano.

CONCLUSIONS

Soy products can be used to replace the majority of fishmeal in the diet of goldenfin pompano (*Trachinotus blochii*). Equivalent fish growth, feed conversion and fish health and survival were found when pompano were fed diets in which fishmeal provided either 45% or 16% of total protein in the feed. A combination of dehulled soybean meal and animal grade soy protein concentrate proved efficient in replacing the majority of fishmeal in the 43/12 pompano diet, when supplemented with methionine. Feed

⁷ Force 10 is the next to highest storm classification on the Beaufort Wind Scale, and is characterized as a severe storm, with very high waves (20-30 ft), overhanging crests, sea white with densely blown foam, heavy rolling; seldom experienced on land, considerable structural damage.

manufacturers are encouraged to include dehulled soybean meal and soy protein concentrate in their ingredient mix as a potential means to reduce feed cost when formulating feeds for pompano.

Adoption of a three-stage production system, in which a portion of the fingerling production was conducted offshore, worked well for improving fish growth and overall health, but both parasitic and bacterial pathogens remained problematic during stage one fingerling production inside Xincun Bay. Frequent formalin bath treatments were required to control parasites that impacted fish health and survival. Pre-treatment gill parasite infestations were sufficient to significantly reduce respiration in fingerling fish. Infectious bacterial pathogens were also identified as problematic during the stage one fingerling period, and required treatment with medicated feed after the pompano were moved offshore. Results of the three-stage production strategy tested in 2007 indicate that the duration of stage one, which takes place wholly inside Xincun Bay, needs to be significantly reduced and that the majority of fingerling production needs to be accomplished offshore. Development of offshore fingerling production techniques is recommended as a priority strategy for the OCAT project, and is strongly recommended for the marine cage farming industry in total in order to improve the sustainability of marine fish culture in the coastal regions of China.

Identification and treatment of parasitic and bacterial pathogens resulted in significant improvements to fish growth and health in comparison to previous OCAT trials. Stocking of healthy pompano into the OCAT cages permitted culture from approximately 75 g to >600 g in 122 days, with >99% fish survival. This represents a 50% increase in pompano growth performance over the four years of OCAT feeding trials (2004-2007), and a substantial increase in fish survival over previous trials in which fish mortality averaged $\geq 25\%$. Having pompano healthy and free of pathogens at the time of stocking into the OCAT cages eliminated the need for pathogen treatment during the 122-day period the fish were in the OCAT cages. Not having to treat fish after transfer to the OCAT cages significantly reduced overall management, labor and disease treatment costs.

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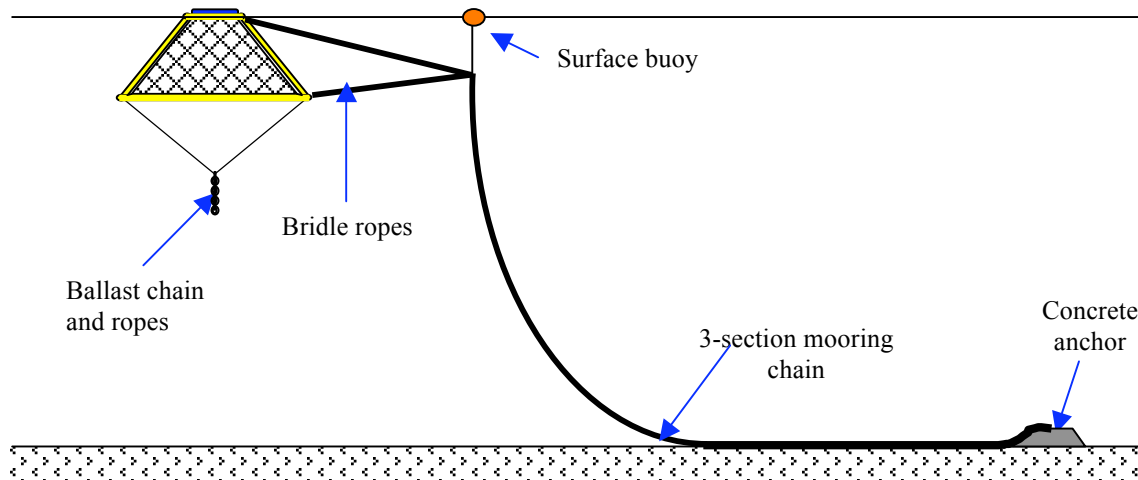


Figure 1. Schematic drawing of the OCAT offshore ocean cage. The cage has a truncated pyramid shape and has a rigid, HDPE pipe frame with a 100-m³ fish culture net suspended inside the cage frame. The cage is anchored with a single point mooring to keep the cage down current. Increased water current velocity will automatically submerge the cage.

Table 1. Formula for the ASA-IM 47/15 marine fingerling feed used in the 2007 OCAT offshore cage feeding trial.¹ The 47/15 feed is used to culture pompano from approximately 5 g to 25 g.

Ingredient	% of feed
Fishmeal, Anchovy 67/8 IFN	40.70
Wheat, Feed Flour 15.4 / 2	23.00
Soy Protein Concentrate 65 cn	13.00
Fish Oil, Anchovy w/eq 200	8.00
Corn Gluten Meal 63.2%	5.00
Blood Meal spray dried 90/0.5	5.00
Soy Oil	2.33
Soy Lecithin / Corn Blend	2.00
Vitamin Premix PMX-F2	0.50
Mineral Premix PMX F-1	0.25
Choline Chloride 50%	0.08
Stay C 35%	0.06
Mold Inhibitor	0.05
Antioxidant	0.03
Total	100.00

¹The numerical reference indicates the percentages of crude protein and crude lipid in the feed. For example, 47/15 indicates the feed contains 47% crude protein and 15% crude lipid.

Table 2. Formula for the ASA-IM 43/12 standard marine growout feed (43/12 STD) used in the 2007 OCAT pompano offshore cage feeding trial.¹ Fishmeal provides 45% of the total protein in the 43/12 STD feed.

Ingredient	%
Soybean Meal 48%	30.00
Fishmeal, Anchovy 67/8 IFN	30.00
Wheat, Feed Flour - 15.4 / 2	21.00
Fish Oil, Anchovy w/eq 200	6.00
Corn Gluten meal 63.2%	5.00
Blood Meal spray dried 90/0.5	2.30
Soy Oil	2.30
Soy Lecithin / Corn Blend	2.00
Calcium phos. mono - 21%	0.50
Vitamin Premix PMX-F2	0.50
Mineral Premix PMX F-1	0.25
Stay C - 35%	0.06
Mold Inhibitor	0.05
Antioxidant	0.04
Total	100.00

¹The numerical reference indicates the percentages of crude protein and crude lipid in the feed. For example, 43/12 indicates the feed contains 43% crude protein and 12% crude lipid.

Table 3. Formula for the ASA-IM 43/12 soy product marine growout feed (43/12 SPC) used in the 2007 OCAT pompano offshore cage feeding trial.¹ The majority of protein in the feed is supplied by soy products. Fishmeal contributes only 16% of the total protein in the 43/12 SPC feed.

Ingredient	%
Soybean Meal - 47.5% IFN	24.00
Soy Protein Concentrate 65 cn	21.30
Wheat Flour - 13.2%	19.60
Fishmeal, Anchovy 65/9	11.00
Fish Oil, Unspecified.	9.30
Corn Gluten Meal 61.5%	5.50
Blood Meal rng. 93/1	5.00
Calcium phos. mono - 21%	2.00
Soy Lecithin	1.00
Vitamin Premix PMX-F2	0.50
Choline Chloride 50%	0.25
Mineral Premix PMX F-1	0.25
MHA (methionine) 84%	0.15
Stay C - 35%	0.06
Mold Inhibitor.	0.05
Antioxidant	0.04
Total	100.00

¹The numerical reference indicates the percentages of crude protein and crude lipid in the feed. For example, 43/12 indicates the feed contains 43% crude protein and 12% crude lipid.

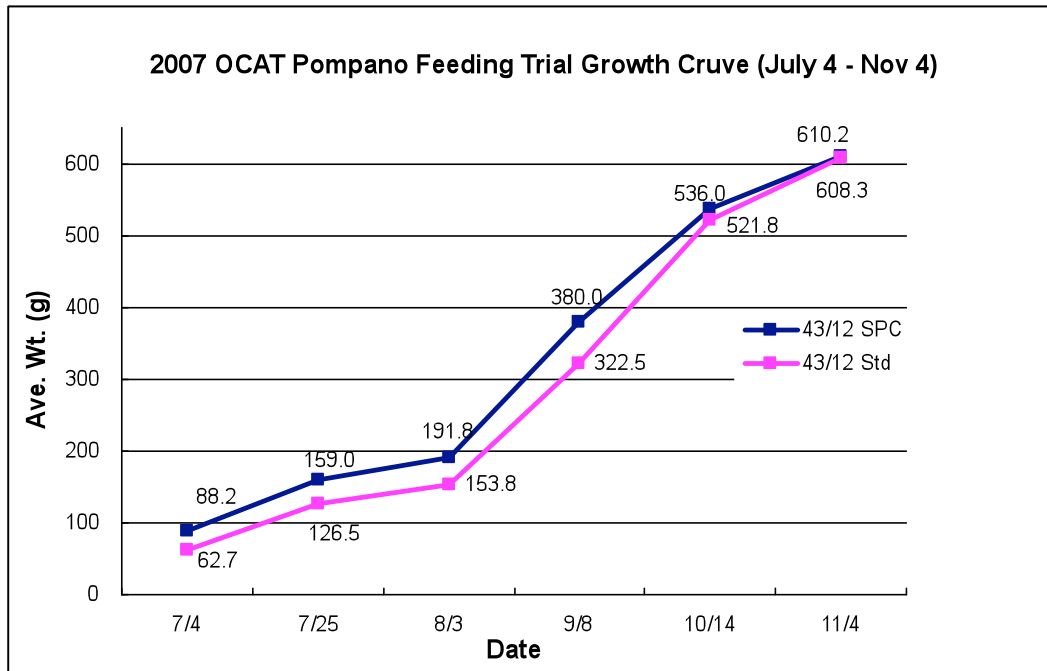


Figure 2. Growth curve for pompano fed 43/12 diets containing varying levels of fishmeal and soy products in the ASA-IM 2007 OCAT offshore cage feeding trial. There was no difference in fish growth when fed either the 43/12 STD or 43/12 SPC feeds. FCR with 43/12 STD and 43/12 SPC feeds averaged 2.51:1 and 2.59:1, respectively.

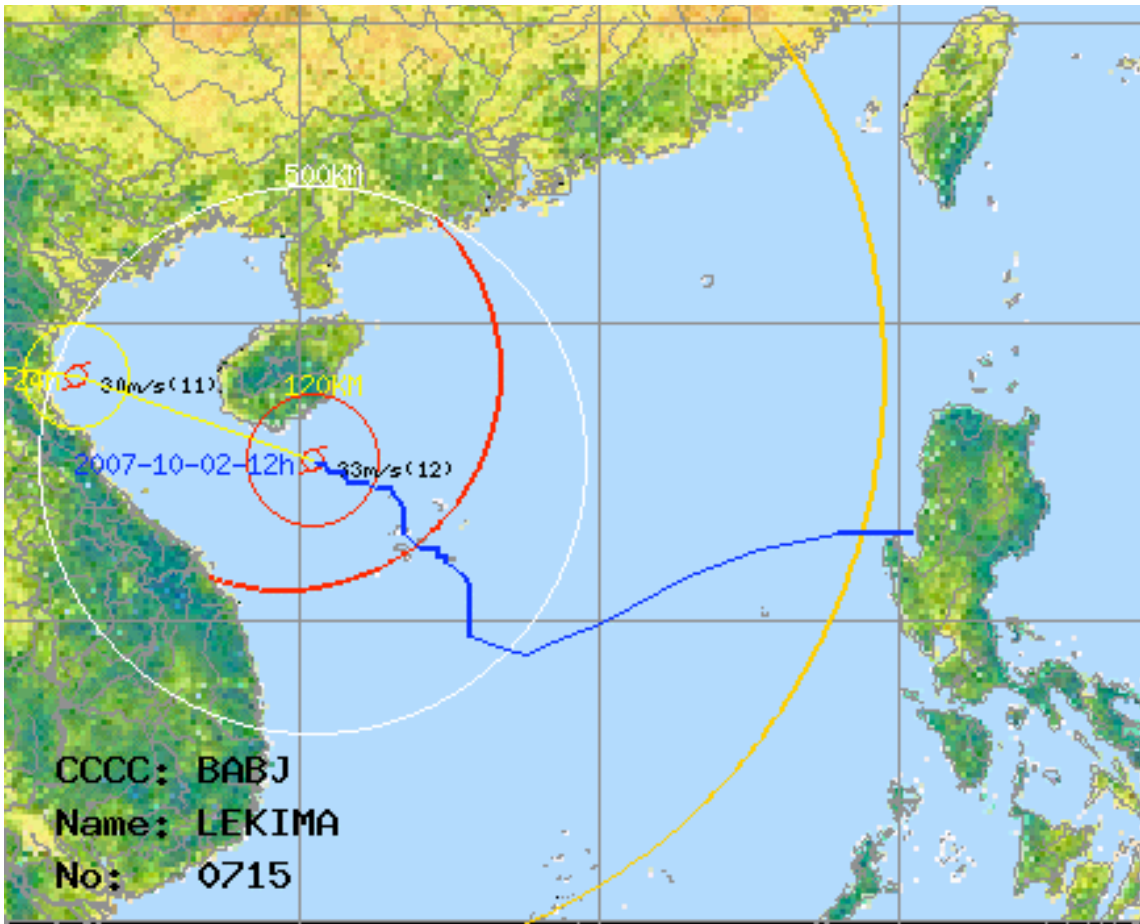


Figure 3. Path of Typhoon Lekima that impacted the OCAT trial site on 2 October 2007. Wind speed at the center of the typhoon was level 12 (120-km/hr). Wind speed at the OCAT trial site was level 10 (100-km/hr) for 12 hours. Courtesy of the Hainan Island Metrology Bureau (<http://mb.hainan.gov.cn/cyclone.htm>)

Table 4. Results of stage one fingerling production with the ASA-IM 47/15 marine fingerling feed in the 2007 OCAT pompano offshore cage feeding trial. Pompano were cultured for 29 days with the 47/15 feed in traditional net cages suspended from a wooden raft frame inside Xincun Bay, Hainan, China.

Cage	Feed	Stocking Density fish/m ³	Initial wt (g)	Final wt (g)	Days	Survival*	Gross prod. (kg)/m ³	FCR
Cage #1	47/15	222	6.6	26.5	29	90%	5.3	0.89
Cage #2	47/15	222	6.7	25.0	29	90%	5.0	0.97
Cage #3	47/15	222	6.6	23.0	29	90%	4.6	1.08
Cage #4	47/15	222	4.9	14.4	29	90%	2.8	1.86
Mean		222	6.2	22.2	29	90%	4.43	1.20

*The estimated pompano survival rate from stocking to fingerling harvest was approximately 90%

Table 5. Results of the 2007 OCAT offshore cage feeding trial that compared pompano production with the standard ASA-IM 43/12 marine fish growout feed (43/12 STD) and a nutritionally equivalent feed (43/12 SPC) in which the majority of fishmeal was replaced with a combination of dehulled soybean meal and soy protein concentrate. Fishmeal contribution to total protein was 45% in the 43/12 STD feed and 16% in the 43/12 SPC feed.

Cage	Feed	Est. Stocking Density fish/cage	initial Wt (g)	Harvest. Wt. (g)	Fed Days	Survival	Gross Prod. kg/m ³	FCR
East	43/12 SPC	9,800	26.5	623.1	146	99.5%	61.3	2.43
North	43/12 SPC	9,400	25.0	597.2	146	99.5%	54.6	2.76
Mean		9,600	25.7	610.2	146	99.5%	58.0	2.59
South	43/12 std	9,300	23.0	640.1	146	99.2%	59.0	2.47
West	43/12 std	9,900	14.4	576.5	146	99.3%	57.2	2.55
Mean		9,600	18.7	608.3	146	99.2%	58.1	2.51