

ZINPRO®

**ADVANCING
PERFORMANCE
TOGETHER**

**Essential
Trace Minerals**
for Exceptional
Performance



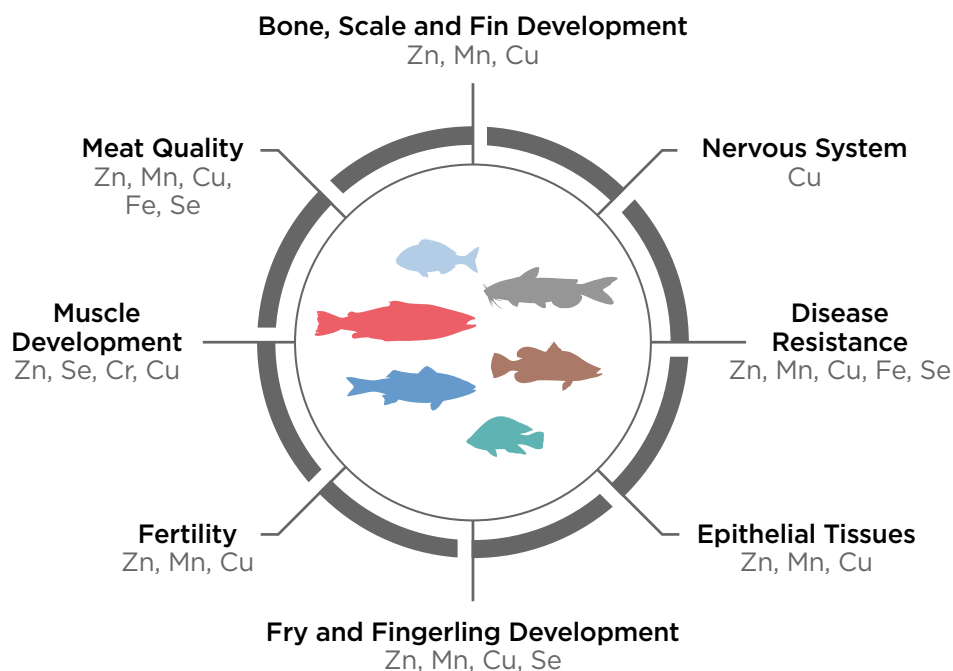
Zinpro Performance Minerals® Deliver Proven Benefits for Salmonid and Marine Fish Performance, Health and Meat Quality

Trace minerals play numerous essential roles within cells and metabolic processes, which makes them vital for the optimal nutrition and health of animals – including salmonid and marine fish.

The molecular design of Zinpro Performance Minerals® (ZPM) guarantees essential trace minerals, such as zinc, manganese, copper, iron, selenium and chromium, are effectively delivered and best utilized by fish for modern aquaculture production. Research shows that supplementing fish diets with Zinpro Performance Minerals is essential for optimizing growth performance, modulating immune system response and improving product quality.

The source and availability of trace minerals are the key to satisfy the needs of finfish in an efficient and sustainable way through their life cycle.

Trace Mineral Benefits in Salmonid and Marine Fish



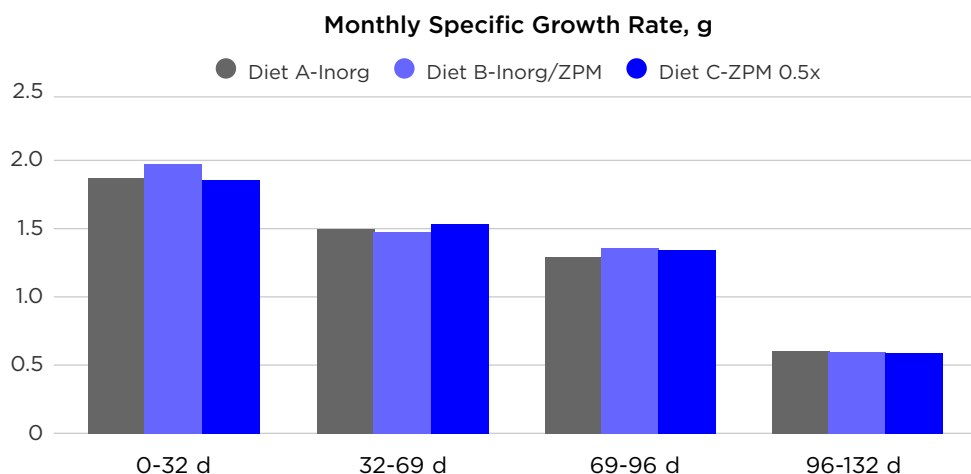
Study 1

Comparison of European Seabass Response to Inorganic Minerals and ZPM (0.5x)

Key Findings

- ZPM supplemented at half the level of inorganic sources maintained growth performance of European seabass (Fig. 1), indicating ZPM is a more effective trace mineral source than inorganic forms.
- Partial or complete replacement of inorganic trace minerals with ZPM significantly ($P < 0.05$) increased the number of goblet cells in the intestine and skin of European seabass (Fig. 2), demonstrating enhanced barrier defense mechanisms against pathogens.
- Activity of glutathione peroxidase (GPx) significantly ($P < 0.05$) increased in fish supplemented with ZPM at half the level of inorganic trace minerals (Fig. 3), indicating ZPM (in particular Availa® Se vs. Selenite), is more effective in sustaining antioxidant capacity in European seabass.

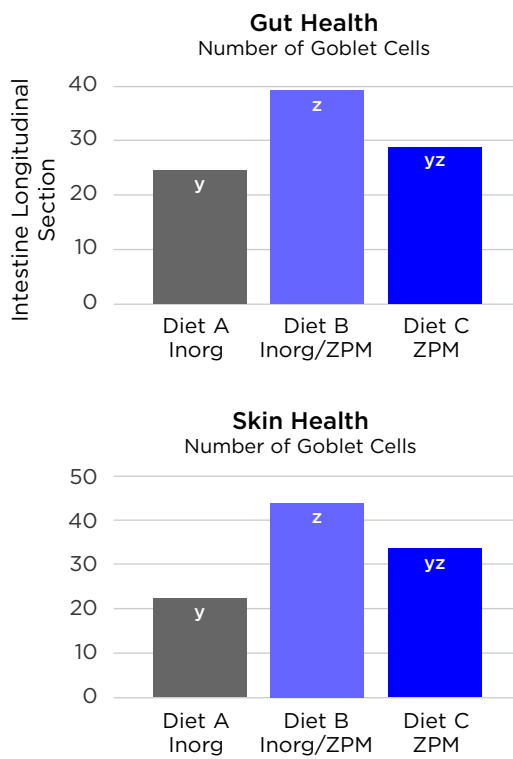
Growth Performance Fig. 1



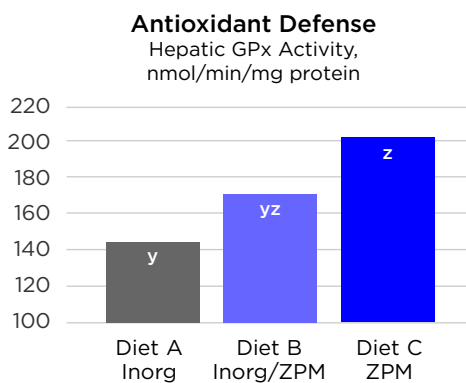
Source: A.C. Figueiredo-Silva, C. Boggino, M. Sun, Maria Mastoraki, I. Papadakis, A. Theodoridou, M. Pavlidis, S. Chatzifotis. Effects of Complexed Trace Minerals at Different Inclusion Rates in Commercial Seabass (*Dicentrarchus labrax*) Diets. Aquaculture Europe, 7-10 October, 2019, Berlin, Germany.



Health Fig. 2



Health Fig. 3



Study Criteria



This study compared the efficacy of ZPM (metal-amino acid complexes) with inorganic minerals (sulfates) in the diet of European seabass. Growth performance and health biomarkers were evaluated.



	Diet A Inorg	Diet B Inorg/ZPM	Diet C ZPM 0.5x
Fe, ppm	80	40	40
Cu, ppm	6	3	3
Zn, ppm	100	50	50
Mn, ppm	24	12	12
Se, ppm	0.24	0.12	0.12



Initial body weight: 15 g
Stocking density: 1.24 kg/m³
Replications: 4
Duration: 120 days
Salinity: 34 ppt



46% CP/18% fat
19% fish meal
8% fish oil
Feeding: 2 times/day to satiation



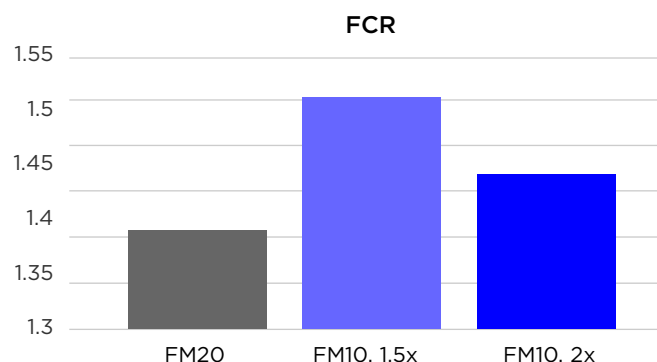
Location:
Hellenic Centre for Marine Research (HMCR) Crete, Greece

ZPM Are a Cost-Effective Solution for Reducing Fish Meal in European Seabass Diets

Key Findings

- Supplementation with ZPM contributes to a cost-effectively reduction of FM from 20 to 10% while respecting EU upper limits for TM supplementation and TM content in sea bass feeds. One exception in this study was that dietary Se could not be kept at or below 0.5 ppm. Ingredient contribution to dietary Se content in aquafeeds, along with the contribution of FM and other marine ingredients, makes it practically impossible to keep Se levels in diets within EU allowed levels.
- By adjusting ZPM premix in FM10 at 1.5, or 2x the level used in FM20, we managed to maintain growth performance (Fig. 2a) and slightly increased the whole body Zn of European seabass (although not statistically significant) (Fig. 2b). Yet, the specific growth rate (SGR) and feed conversion ratio (FCR) were superior when TM premix was adjusted at 2x compared with 1.5x that in FM20.
- Results indicated that adjusting the dietary TM content of FM10 to similar levels of that in FM20 may not be enough to sustain the performance of European seabass. Increasing the TM inclusion level from 1.5 to 2x that of FM20 improved FCR (Fig. 1) and SGR (Fig. 2a) by 3 and 5% respectively. These levels are closer to that seen with FM20. This may be at least partly explained by the likely lower nutrient availability in FM10 as a result of its higher plant protein content and antinutritional factors compared to FM20 diet.
- This strategic approach resulted in a 8.5% feed cost savings which supports a more sustainable, cost efficient solution to the aquaculture industry.

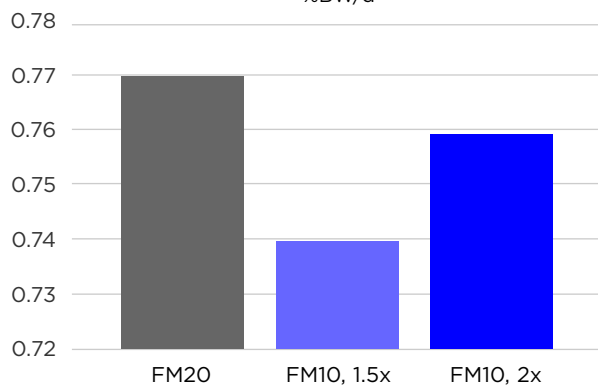
Growth Performance Fig. 1



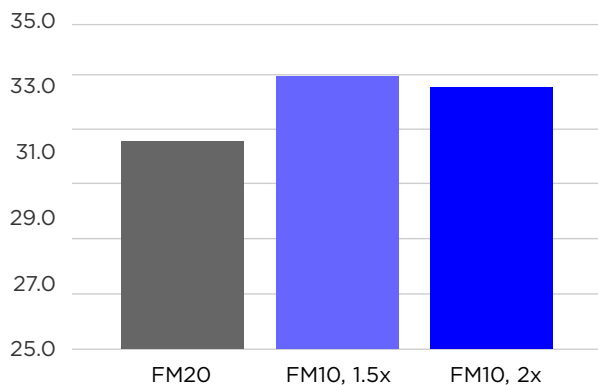


Growth Performance Fig. 2

2a. Specific Growth Rate
%BW/d



2b. Whole Body Zn Content, ppm



Study Criteria



This study evaluated that adjusting the inclusion of a complete metal-AA complex premix contributed to a cost-effective reduction of FM from 20 to 10% in European sea bass diets.



ppm	FM20	FM10, 1.5x	FM10, 2x
Fe, Availa Fe	40.1	60.0	80.0
Cu, Availa Cu	3.0	4.5	6.0
Zn, Availa Zn	50.1	75.0	100.0
Mn, Availa Mn	12.0	18.0	24.0
Se, Availa Se	0.12	0.18	0.20



Initial body weight: 47 g
Density: 3.5 kg/m³
Replications: 4
Duration: 12 weeks
Salinity: 34 ppt



48% CP/16% fat
Feeding: 2 times/day to satiation



Location:
Hellenic Centre for Marine Research (HMCR), Crete, Greece

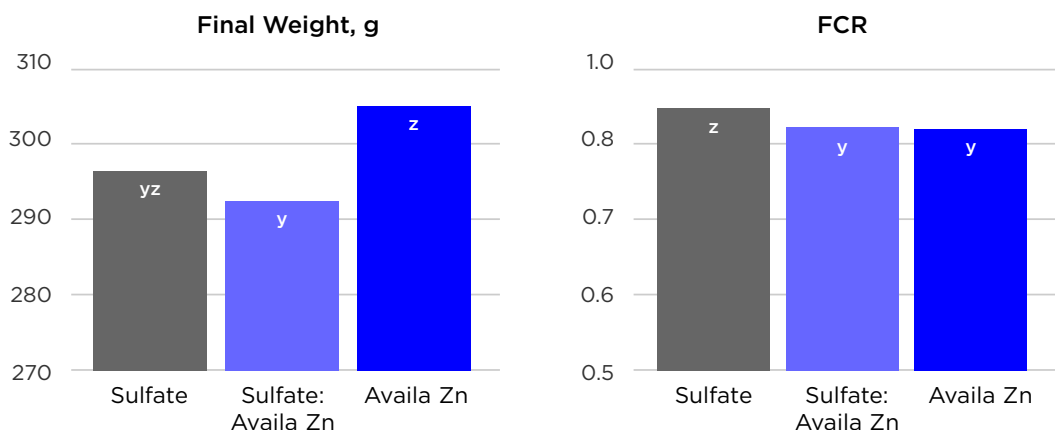
Study 3

Availa® Zn Improves Atlantic Salmon Growth and Resistance to Sea Lice

Key Findings

- Availa Zn supplemented at half (60 ppm) the level of inorganic zinc (120 ppm) resulted in a numerically higher body weight and significantly ($P < 0.05$) improved FCR of Atlantic salmon (Fig. 1).
- Furthermore, Availa Zn supplemented at half the level of inorganic zinc was significantly ($P < 0.05$) more efficient in reducing *Caligus* abundance in salmon (Fig. 2).
- Skin score evaluation indicated fish fed Availa Zn had a more desirable level of skin integrity than fish fed either diet containing inorganic zinc (Fig. 3).
- In this study, best performance and health results were found with a 20% fish meal diet supplemented with 60 ppm Availa Zn. Yet, the required supplementation levels of zinc, like of other essential trace minerals, is expected to increase as their level and availability is becoming severely limited through progressive replacement of fish meal with plant proteins.

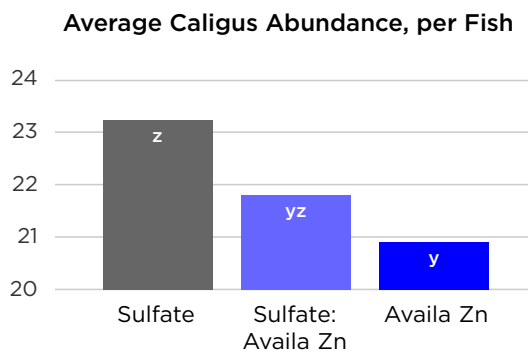
Growth Performance Fig. 1



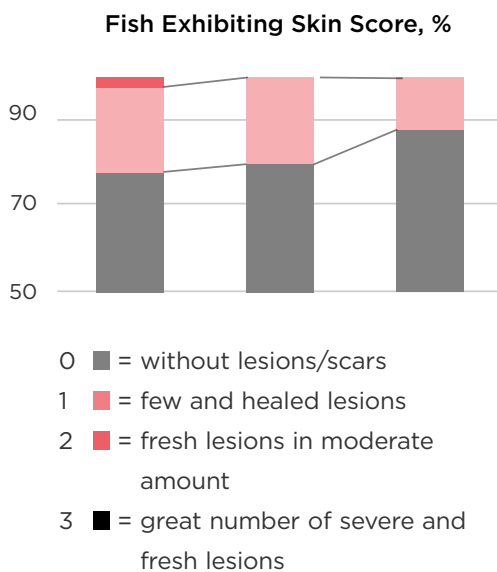
Source: Mihai Sun, Alba K. Fireman, Terry L. Ward, Claudia V. Pavez, and Javier Alcaíno. Growth Performance, Skin Strength and Consequent Infestation of Sea Lice *Caligus rogercresseyi* on Atlantic Salmon (*Salmo salar*) Fed with Availa Zn. 2017 World Aquaculture Society, Latin American & Caribbean Chapter, November 7-10, 2017, Mazatlán, Mexico.



Health Fig. 2



Health Fig. 3



Study Criteria



The objective of this study was to evaluate the impact of supplemental zinc sources and levels on growth performance and the resistance of Atlantic salmon (*Salmo salar*) against sea lice (*Caligus rogercresseyi*).



	Zn Supplementation, ppm	
	ZnSO ₄	Availa Zn
Sulfate	120	-
Sulfate: Availa Zn	60	60
Availa Zn	-	60



Initial body weight: 118 g
 Stocking density: 45 fish/tank (600 L)
 Replications: 4
 Duration: 80 days
 (60 d growth + 20 d Caligus challenge)
 Salinity: 32 ppt



47% CP/20% fat
 20% fish meal
 6% fish oil
 Feeding: 2 times/day to satiation



Location:
 Fundación Chile;
 Puerto Montt, Chile

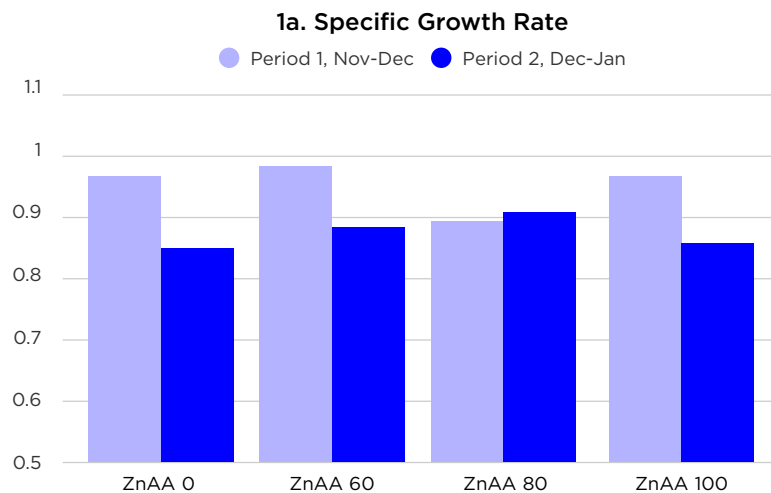
Study 4

Zn Deposition in Atlantic Salmon Responds Linearly to Zn Supplementation During Smoltification Phase

Key Findings

- Supplementation of salmon diets with 0 to 100 ppm Zn in the form of ProPath® Zn, significantly improved the dietary Zn digestibility from 37 to 44% (16% increase, Fig. 2a) without significantly affecting the performance of salmon (Fig. 1a), during the smoltification period.
- Supplementation of salmon diets with Zn did not affect specific growth rate (SGR) and feed conversion ratio (FCR) at the end of the 12 week feeding period, but seemed to improve SGR and FCR during the smoltification period (Period 2, last 4 wks of the study). Although not statistically significant, supplementation with 80 ppm Zn increased SGR by 7% (Fig. 1a) and reduced FCR by 6.5% (Fig. 1b).
- Supplementation with 100 ppm Zn increased whole body and skin Zn contents by 1.7x and 2.5x, respectively (Fig. 2a and 2b), confirming that although responding positively to increasing Zn supplementation, Zn digestibility is not the most precise response criteria to evaluate fish response to Zn.
- Whole body and skin Zn deposition responded linearly to increased Zn supplementation up to 100 ppm, indicating that a higher Zn supplementation may be required during the smoltification period, requiring further investigation.
- Basal diets containing 60 ppm of Zinc contributed from raw material.

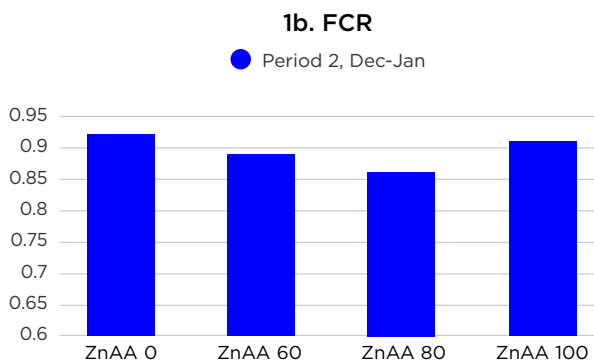
Growth Performance Fig. 1



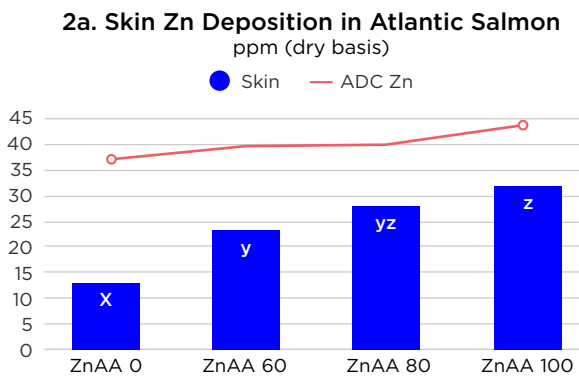
Source: Zinpro Corporation 2021. Effect of ProPath on Salmon Smoltification. Internal Report.



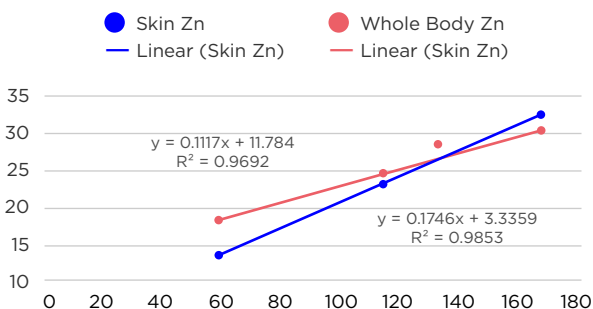
Growth Performance Fig. 1



Growth Performance Fig. 2



2b. Relationship between dietary Zn level and Zn content in whole body (wet basis) and skin (dry basis), ppm



Study Criteria



This study was designed to assess the optimum level of supplemental ProPath Zn in the diet of Atlantic salmon during the smoltification period. ProPath Zn was evaluated based on zinc deposition in skin and whole body.



Treatment	Zn, ppm ProPath Zn
ZnAA 0	0
ZnAA 60	60
ZnAA 80	80
ZnAA 100	100



Initial body weight: 43 g
 Density: 60 fish/ 0.5m³ tank
 Replications: 4
 Duration: 12 weeks divided in Period 1 and Period 2.

- Period 1: 20Oct-2Dec, before (L:D, 24:0) and winter signal period (L:D, 12:12)
- Period 2: 2Dec-3 Jan, Smoltification period (L:D, 24:0)

Salinity: 0 ppt



45% CP/ 20% fat
 16% FM, 21% SPC, 12.5% CGM, 12% WG
 Feeding: In excess for max feed intake/ automatic feeders



Location:
 Nofima, Sunndalsøra, Norway

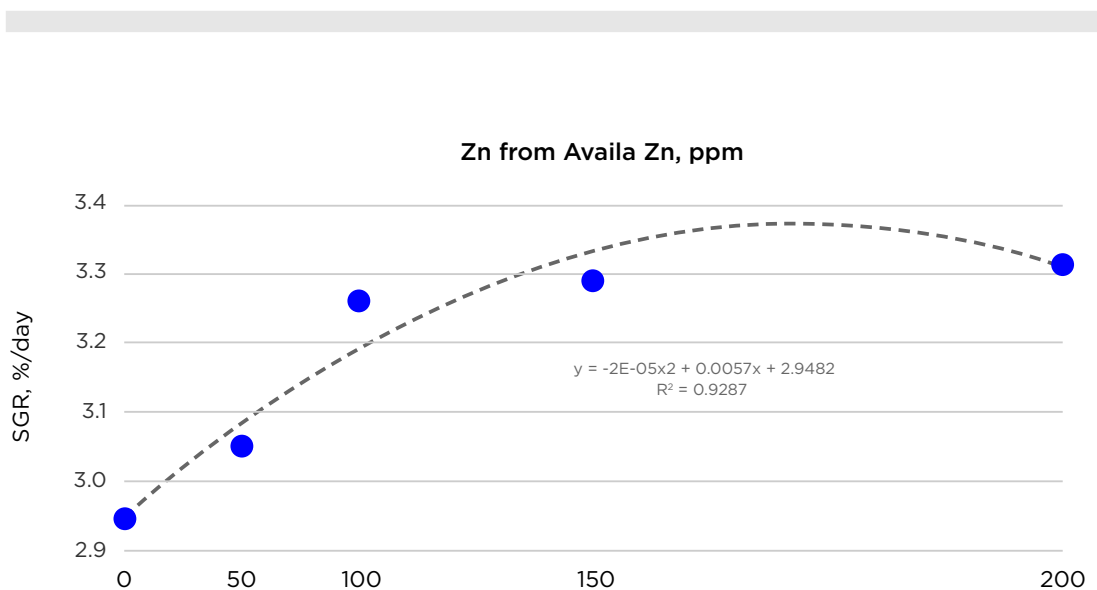
Study 5

Effects of Availa® Zn on Asian Seabass Growth Performance and Zinc Deposition

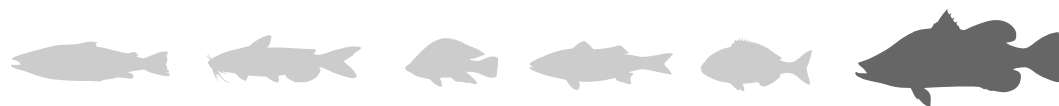
Key Findings

- Increasing the zinc levels sourced from Availa Zn from 0 to 50 ppm significantly ($P < 0.05$) improved specific growth rate (SGR) (Fig. 1).
- Availa Zn supplementation increased whole body and bone zinc content (Fig. 2).
- Results suggest that 50 ppm zinc from Availa Zn is the minimum supplemental level for Asian seabass under the conditions of this study which were used to promote growth performance and deposition of zinc for body reserves.

Growth Performance Fig. 1



Source: Orapint Jintasataporn, Terry Ward, Srinoy Chumkam and Oratai Jintasataporn. The Optimum Dose and Relative Bioavailability of Zinc Amino Acid Complex in Diet for Asian Seabass (*Lates calcarifer*, Bloch 1790). International Symposium on the Feeding and Nutrition of Fish, June 5-10, 2016, Sun Valley, Idaho, USA.



Growth Performance Fig. 2

Body and Tissues Zinc Deposition

Zn, mg/kg	Treatment				
	Control	Availa Zn 25	Availa Zn 50	Availa Zn 100	Availa Zn 200
Whole Body	12.64	13.87	12.38	12.23	11.74
Bone	47.03	47.97	51.85	53.45	52.68
Liver	12.20	16.55	19.27	18.62	18.22
Fillet	5.22	5.95	6.38	6.76	7.36

Study Criteria



This study was designed to assess the optimum level of supplemental Availa Zn in the diet of Asian sea bass (*Lates calcarifer*). Availa Zn was evaluated based on parameters measured for zinc deposition and growth performance.



Treatment	Zn, ppm Availa Zn
Control	0
Availa Zn 25	25
Availa Zn 50	50
Availa Zn 100	100
Availa Zn 200	200



Initial body weight: 3.5 g
Density: 40 fish/tank (500 L)
Replications: 4
Duration: 8 weeks



47% CP/8% fat
Feeding: 3 times/day, 2-3.5% BW



Location:
Kasetsart University Bangkok,
Thailand

Essential Trace Minerals for Salmonids and Marine Fish

BENEFIT	TRACE MINERALS	HOW IT WORKS
Disease Resistance	Zinc, Manganese, Copper, Selenium, Iron	<ul style="list-style-type: none"> • Humoral immunity • Cell-mediated immunity • Non-specific immunity • Antioxidant activity to remove free radicals and protect cell membranes
Bone, Scale and Fin Development	Zinc, Manganese, Copper, Selenium, Iron	<ul style="list-style-type: none"> • Bone matrix development and maintenance • Cell division and protein synthesis for normal tissue mineralization
Skin and Gut Integrity	Zinc, Manganese, Copper	<ul style="list-style-type: none"> • Improves wound healing • Epithelial tissue integrity through maintenance of cell division, protein synthesis and antioxidant activity to remove superoxide radicals
Fertility	Zinc, Manganese, Iron, Copper, Selenium	<ul style="list-style-type: none"> • Reproductive hormone synthesis: steroidogenesis • Helps avoid or reduce nutritional anemia • Female maturity and fertility • Egg development • Egg viability • Hatching rate • Sperm maturation and quality • Key to normal ovarian function
Muscle Development	Zinc, Copper, Selenium, Chromium	<ul style="list-style-type: none"> • Enzyme systems required for growth • Energy and protein metabolism • Cell membrane protection from peroxides • Influences carbohydrate, lipid and protein metabolism
Early Stage Development	Zinc, Manganese, Copper, Selenium	<ul style="list-style-type: none"> • Energy and protein metabolism • Cell proliferation • Normal tissue mineralization • Cell membrane protection • Hemoglobin formation
Meat Quality	Zinc, Selenium, Chromium, Iron	<ul style="list-style-type: none"> • Cell membrane protection • Antioxidant activity • Influences carbohydrate, lipid and protein metabolism • Enhanced meat color • Reduced drip loss

Feeding Recommendations

Mineral	Zinpro Performance Minerals® Products	Zinpro Recommendations
		Minimum Requirement ZPM, mg/kg diet
		Coldwater Fish and Salmonids
Zn	Availa® Zn ProPath® Zn	80
Cu	Availa® Cu ProPath® Cu	10
Mn	Availa® Mn ProPath® Mn	30
Fe	Availa® Fe ProPath® Fe	100
I ^a		1
Se ^b	Availa® Se	0.3
Cr ^c	MICROPLEX® Availa® Cr	0.4

^a Not a current ZPM source

^b Note upper limit allowed in EU is of 0.2 ppm, provided as organic source

^c Use where commercially available



Trace minerals are essential nutrients for salmonids and marine fish.



When animals and
people experience better
health and wellbeing,
**we see a healthier,
more productive and
sustainable world for all.**



For more information:
contact your Zinpro
representative or visit
zinpro.com/aquaculture