

「農業生物經濟未來產業契機研討會」

臺灣水產養殖科技趨勢與
產業化發展

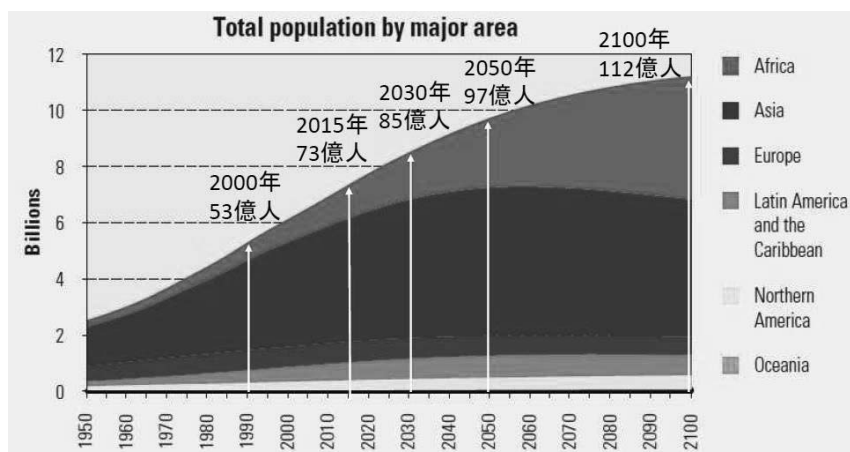


臺灣海洋大學 水產養殖學系

周信佑

2019/10/02

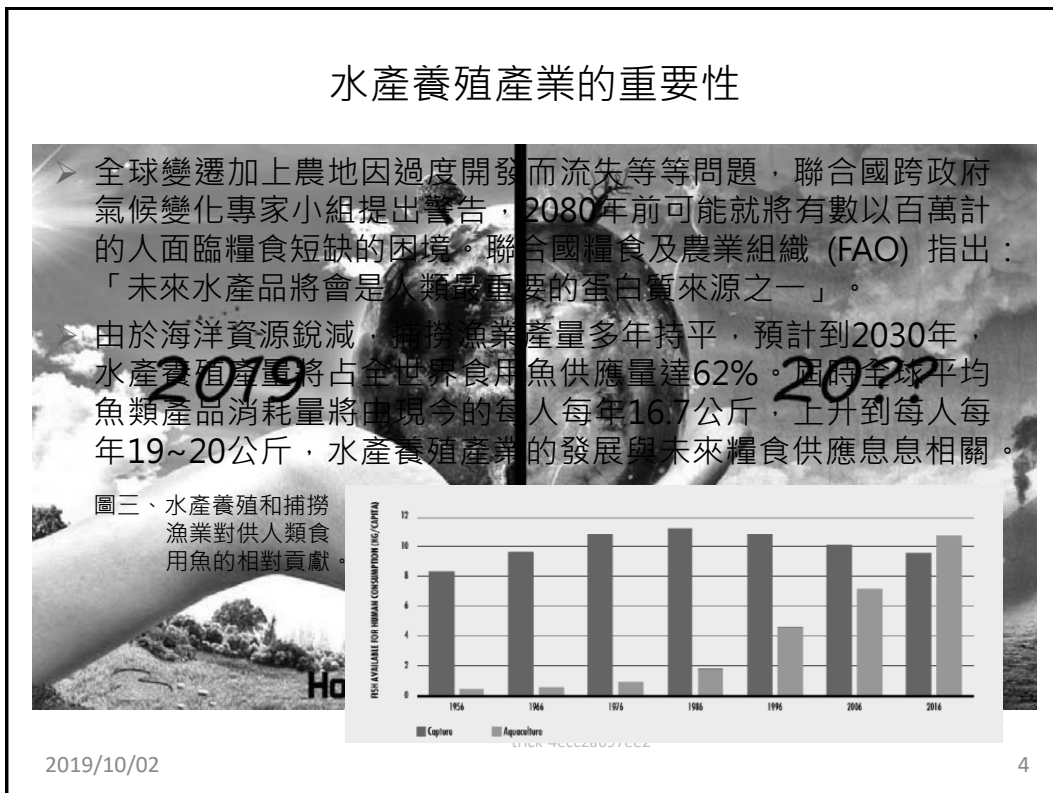
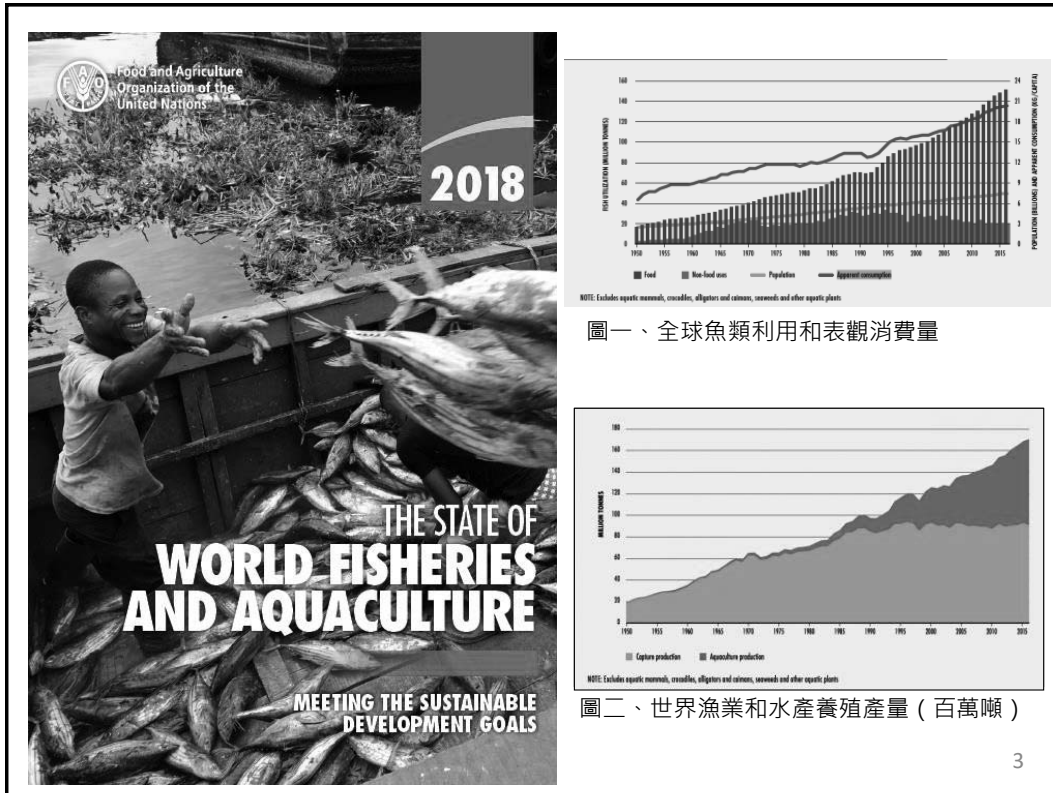
2050年全球人口將達100億人，其中80%在亞洲和非洲，
食物，水，能源等短缺將會是重要議題。




World Population Prospects, The United Nations (Rev. 2015)

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負責任的水產養殖


(FAO: Responsible aquaculture production)

- ◆ 實現對環境生態以及資源沒有不利影響的水產養殖。
- ◆ 為了環境和下一代著想的永續水產養殖業。

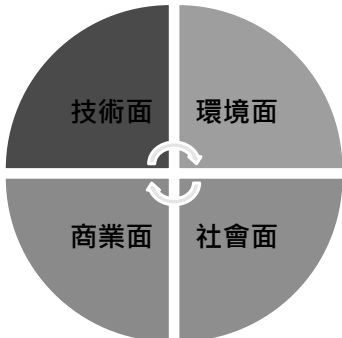
- 1) 適當實施水產養殖飼料生產 (2001年)
- 2) 負責任水生動物的健康管理 (2007年)
- 3) 基因資源管理 (2008)
- 4) 生態系統在水產養殖中的應用 (2010年)
- 5) 使用天然魚作為水產養殖飼料 (2011年)
- 6) 天然幼苗用於水產養殖 (2011年)

Food and Agriculture Organization of the United Nations
国立研究開発法人 水産研究・教育機構 増養殖研究所

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台灣水產養殖產業所面臨的問題



- 1) 台灣地狹人稠，水土資源的不當利用，導致產業發展的脫序現象。
- 2) 病害問題持續威脅產業的發展。
- 3) 養殖經營成本不斷提升產業發展從而受阻。
- 4) 不當管理導致養殖對生態環境與沿岸資源造成衝擊與破壞。
- 5) 國內市場受局限，國際市場競爭激烈，產銷失調且銷售管道不暢，導致魚賤傷漁的惡性循環。

《科學發展》2005年1月，385期，42 ~ 49頁


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支持水產養殖業用續發展的創新技術

- 1) 育種技術的推動並建立穩定供應技術
- 2) 幼苗品質以及飼料質量的改良
- 3) 提高飼料利用效率以減少魚粉的使用
- 4) 發展複合式養殖以減少環境負擔
- 5) 改進養殖魚類的健康管理技術
- 6) 通過智慧網絡促進資訊交流
- 7) 建立法律制度控管藥物和抗生素的使用

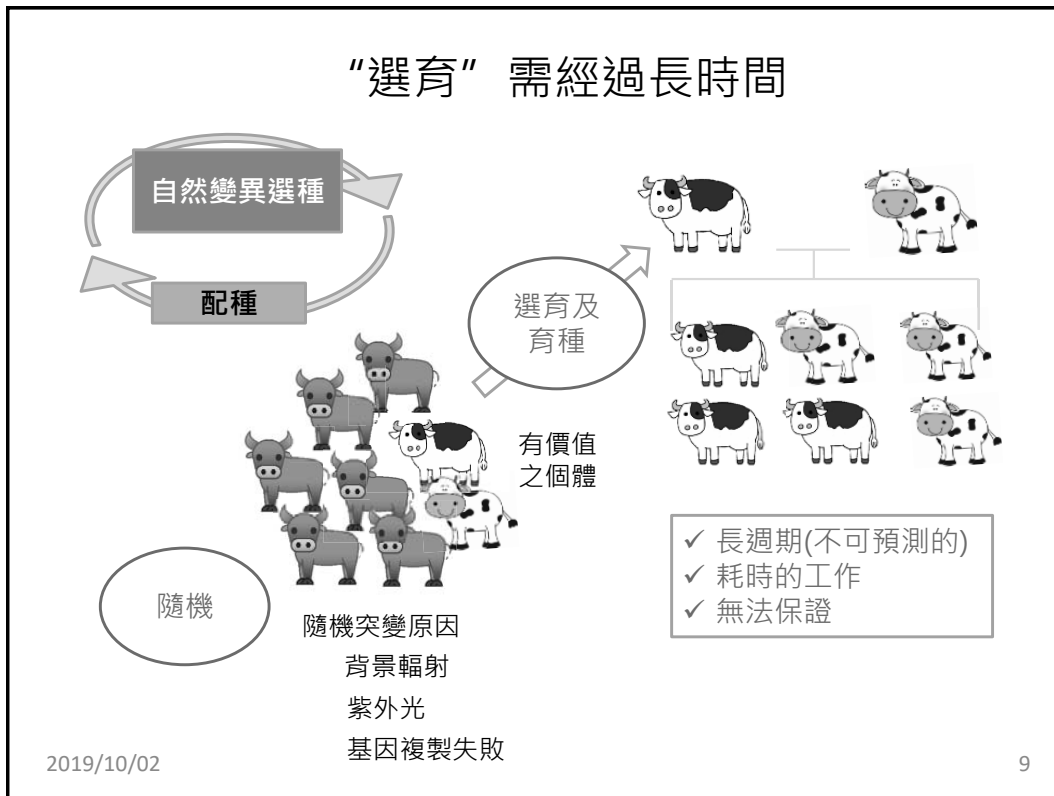
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養殖動物遺傳改良

1. 選育 (Selective Breeding)
 - 狗、比利時藍牛、金魚、錦鯉
 - 鮭魚、吳郭魚 GIFT
 - 標誌輔助選育(MAS)
2. 基因轉殖 (Transgenesis)
 - 生長激素基因轉殖鮭魚、鯉魚、吳郭魚
 - 抗菌肽基因轉殖虹鱔
 - 基因轉殖螢光觀賞魚
3. 標靶基因體標輯 (Targeted Genome Editing)
 - TALEN, CRISPR/Cas9
 - 超肉豬 (Super muscly pig)

2019/10/02 From: 台海大龔紘毅



促進新性狀產生的生物技術

➤ 基因轉殖

在1992年基轉外源生長激素基因鮭魚已經產生。但被大眾接受的難度高，因為藏有外源性基因。

IT WAS THIS BIG! HOW GM SALMON IS ENGINEERED

Chinook Salmon: Gene for protein-coding sequence is taken and inserted into the fertilized egg

Ocean Trout: Gene for antifreeze protein is taken and inserted into the fertilized egg

Fertilized egg

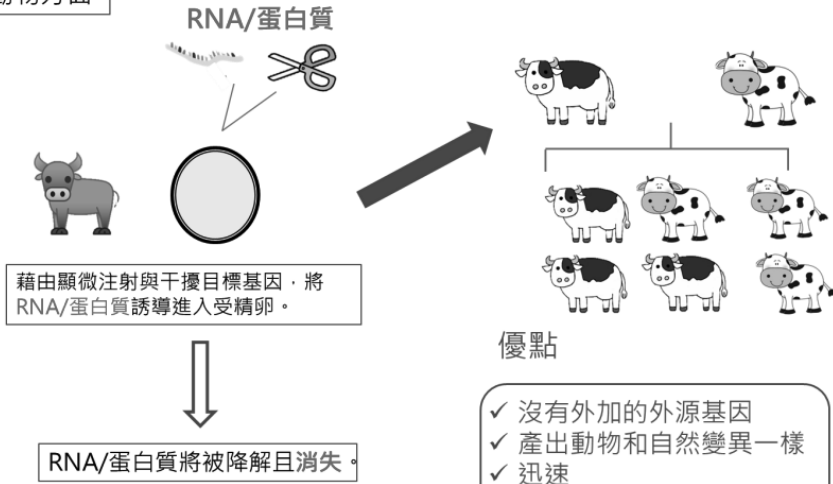
GM Salmon

2019/10/02 <https://www.maritimeinjurylawyersblog.com/wpcontent/uploads/sites/155/2018/05/GMO-Salmon.jpg> 10

➤ 基因體編輯

新產生技術(在2010年後建立)·精確的基因標的不會引入外源基因·產物將被大眾接受的機會高。

動物方面



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A genetically engineered salmon (top) grows twice as fast as its wild counterpart (bottom).

BIOTECHNOLOGY

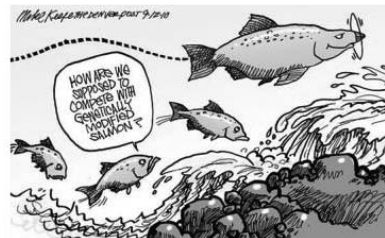
Nature (2013) 497: 17-18

Transgenic salmon nears approval

Slow US regulatory process highlights hurdles of getting engineered food animals to dinner tables.

FDA has determined that the AquAdvantage salmon (GH transgenic salmon) is as safe to eat as Non-GE salmon

Nov.19, 2015

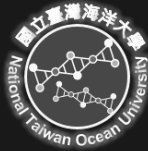


<https://www.abs-canada.org/uncategorized/why-the-fuss-about-gm-salmon/>

2 MAY 2013 | VOL 497 | NATURE | 17

Aquatic Genetics & Molecular Breeding Team in Taiwan

National Taiwan Ocean University



The Genetics & Breeding Group

Department of Aquaculture

黃章文
Dr. Chang-Wen Huang

徐德華
Dr. Te-Hua Hsu

龔紘毅
Dr. Hong-Yi Gong

Quantitative Genetics
Marker Assisted Selection

Population Genetics
Aquaculture expert

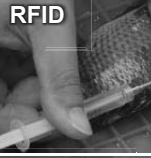
Molecular Genetics
Precision Breeding

Academia Sinica

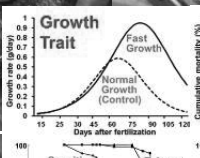
Dr. Chung-Yen Lin 林仲彥
Bioinformatics
Institute of Information Science,
Academia Sinica, Taiwan



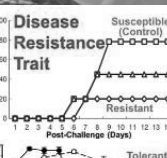
Collecting and establishing of Taiwan tilapia broodstock



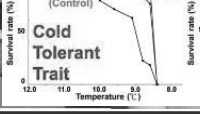
RFID



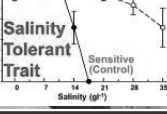
Growth Trait




Disease Resistance Trait




Salinity Tolerant Trait




Cold Tolerant Trait



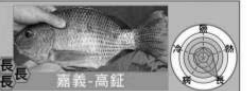
Growth traits




台南-益華




台南-勇吉




嘉義-高鈺




紅-屏東-聖麟-紅尼羅




海大-抗病 (NT1)




海大-成長 (NT2)




海大-耐低溫




海大-耐鹽




七堵基隆河-似尼羅




新北雙溪-似尼羅




新竹香山-似尼羅




苗栗苑裡-似歐利亞




台中旱溪-似莫三比克




新北貢寮-似吉利




台中筏子溪-似歐利亞




台南安平-似莫三比克



The Center for Aquatic Organisms and Conservation



Private hatchery



Different kinds of pools for seeds production and aquaculture

Establishment of functional genetic markers

Gene List

Showing 1 to 3 of 3 entries.

1. **1014637020** *Gene* *Gene Value* *Note* *Time* *Operation*

2. **1014637021** *Gene* *Gene Value* *Note* *Time* *Operation*

3. **1014637022** *Gene* *Gene Value* *Note* *Time* *Operation*

COG

GO

KEGG

耐寒/熱/鹽、成長及性別QTL-seq資料庫

Tri-nucleotide repeat motifs

AAC/GTT	930	9.26%
AAG/CTT	1111	11.06%
AAT/ATT	1161	11.56%
ACC/GGT	589	5.86%
ACG/CGT	68	0.68%
ACT/AGT	92	0.92%
AGC/CTG	1893	18.85%
ATG/CCT	3055	30.41%
ATC/GAT	1007	10.02%
CCG/CGG	139	1.38%

Di-nucleotide repeat motifs

AC/GT	12351	69.35%
AG/CT	3803	21.35%
AT/AT	1562	8.58%
CG/CG	74	0.42%

SSR&SNP marker database

SNP type Nile tilapia

A-G	146,850
C-T	146,335
Transition	293,185
A-C	31,142
A-T	28,374
C-G	35,000
G-T	31,406
Transversion	125,922
Total	419,107

Marker Assisted Selection (MAS)

Parental fish (P0)

Phenotypic distribution of cold and salt tolerance

Sensitive fish (FNT, WGS) × **Resistant fish** (WRF)

Challenged offspring (F1)

	WRF	WYL	FYH	FNT
WRF	110	100	100	148
WYL	100	100	100	100
FYH	100	100	100	100
FNT	172	100	100	87

Hybrid progeny cold/heat/salt tolerant trait test

Marker Assisted Selection (MAS) Diagram

Gene: *CR* (Resistance) vs *CS* (Sensitivity)

Parental: *CR/CR* (Resistant) × *CS/CS* (Sensitive)

F1: *CR/CS* (Resistant)

F2: *CR/CR* (Resistant) × *CS/CS* (Sensitive)

Blue Tilapia (oreochromis aureus) × Nile Tilapia (oreochromis niloticus)

WY (♀) × YY (♂)

WYF₂ (♀) × YYF₂ (♂)

WYF₂ × YYF₂ (回交 F₂ 後代)

WYF₂ × YYF₂ (回交 F₂ 後代)

魚苗抗逆測試

Cold challenge experiments

Temperature: 14°C, 13°C, 12°C, 11°C, 10°C, 9°C, 8°C, 7°C, 6°C

Cross strains: SC1 (n=110), SC2 (n=172), SC3 (n=148), SC4 (n=87)

Survival rates at 10°C: AA (7.30 ± 0.23), Ad (8.35 ± 0.49), Ad (8.47 ± 0.31), dd (10.47 ± 0.70)

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- ▶ 2015年中科院發佈抗生素污染地圖 (Zhang et. al., 2015) · 新聞報導的標題：「觸目惊心」· 中科院发布抗生素污染地图 · 「这个春节你吃了多少抗生素？」
- ▶ 基於健康考量 · 2006年歐盟全面禁止食品動物促生長飼料添加劑 · 而美國亦由於抗藥性隱憂日增 · FDA 頒布新規範 · 【使用抗藥性藥物應有獸醫處方籤】 · 來防止抗藥性細菌的產生。

Comparison of antibiotics sold for animal and human use, in millions of pounds sold, 2001-11

Year	Antibiotics sold for meat and poultry production (millions of pounds)	Antibiotics sold to treat sick people (millions of pounds)
2001	~7.7	~7.7
2002	~7.7	~7.7
2003	~7.7	~7.7
2004	~7.7	~7.7
2005	~7.7	~7.7
2006	~7.7	~7.7
2007	~7.7	~7.7
2008	~7.7	~7.7
2009	~7.7	~7.7
2010	~7.7	~7.7
2011	29.9	7.7

Sources: IMS Health Inc. (human sales data); Animal Health Institute survey of its members, 2001-07; U.S. Food and Drug Administration, 2009-11 (animal sales data).

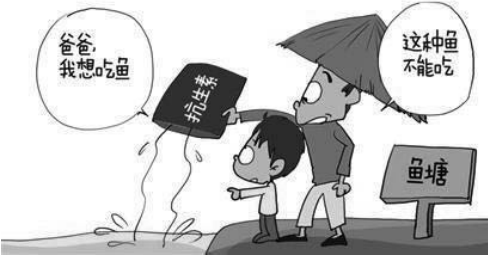
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無抗養殖

目前一般畜牧業使用抗生素的目的：

- (1) 預防疾病
- (2) 用於治療疾病
- (3) 將低劑量抗生素劑添加於飼料中促進生長 (Antibiotic Growth-Promoters, AGP)

歐盟自2006年起全面禁止在食用動物的飼料鐘添加非治療用途的抗菌劑 (AGP) · 而「無抗菌劑促生長飼料添加劑飼養」即簡稱「無抗飼養」。



The cartoon shows a child pointing to a sign that says 'Antibiotics' (抗生素) and saying 'Dad, I want to eat fish' (爸爸, 我想吃魚). The adult, holding an umbrella, replies 'This kind of fish cannot be eaten' (這種魚不能吃) and points to a sign that says 'Fish Pond' (魚塘).

三天下 請輸入關鍵字

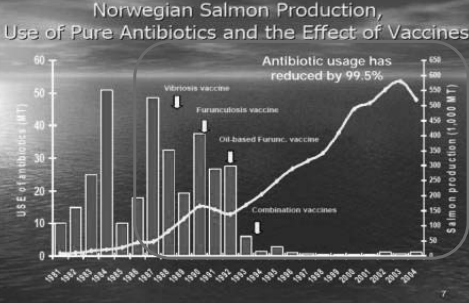
挪威漁民黃金身價

瀏覽數: 28309

作者: 第一書 2012-07-06 天下雜誌264期

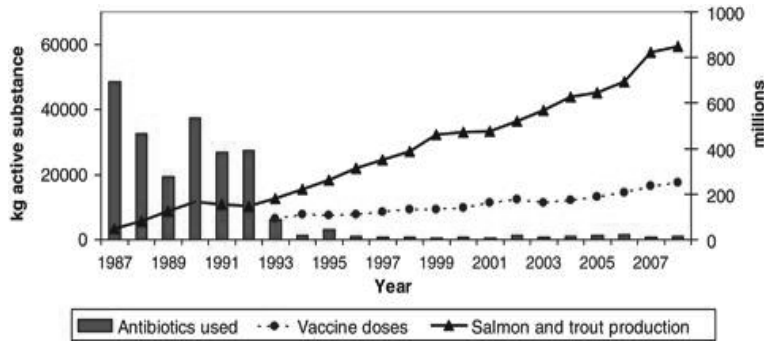
台灣人吃的鮭魚，每兩條就有一條是從挪威進口。當台灣漁民逐漸老去凋零，挪威漁民的個人產值是台灣科技新貴的三倍。從捕魚到海上養殖，挪威如何將漁業提升為高科技、高產值的未來產業？

Norwegian Salmon Production, Use of Pure Antibiotics and the Effect of Vaccines



Antibiotic usage has reduced by 99.5%

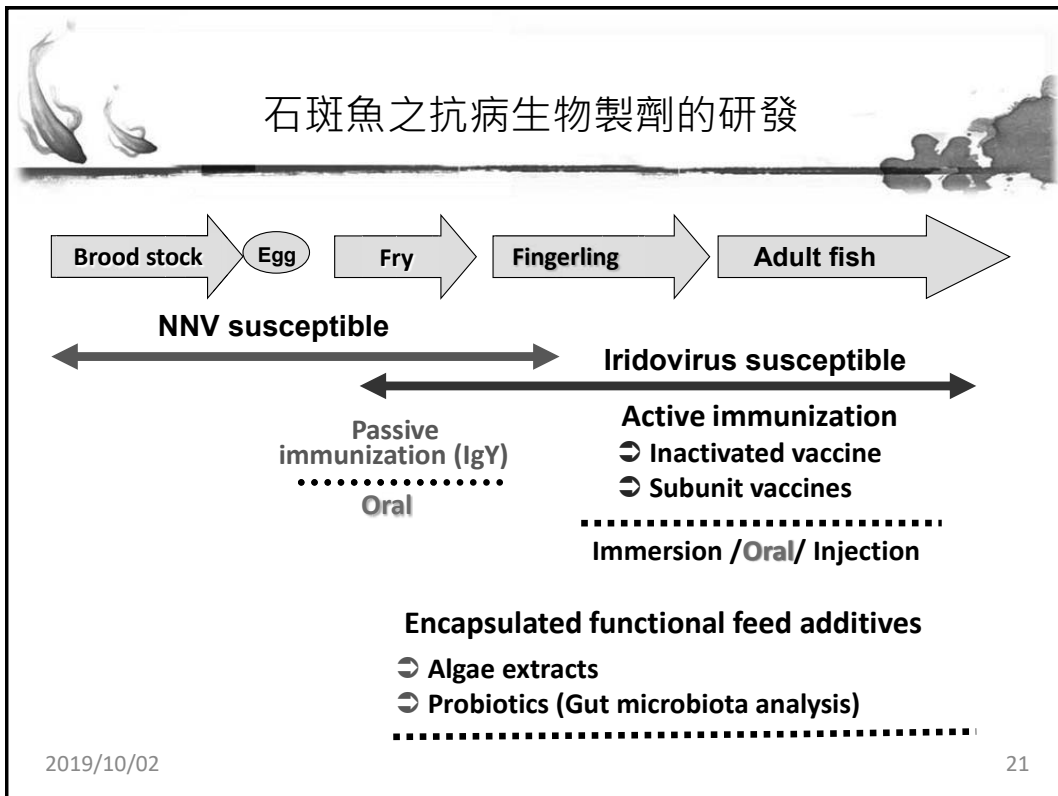
From: Fish Vaccination – A brief overview, Dr Marian McLoughlin



Legend: ■ Antibiotics used ··· Vaccine doses ▲ Salmon and trout production

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Vaccine development : 1 - inactivated vaccine

Efficacy and safety tests of inactivated vaccine

30 days vaccination	Control			F - I			F - II			F - III			BPL - I			BPL - II			BPL - III		
	All died	Lived	Died	All lived	Lived	Died	All lived	Lived	Died	All lived	Lived	Died	All lived	Lived	Died	All lived	Lived	Died	All lived	Lived	Died
Virus resolution (%)	20/20*	1/2	18/18	0/20	7/20	2/4	16/16	1/3	17/17	3/8	12/12	100%	50%	100%	33.3%	100%	100%	100%	37.5%	100%	100%
PCR detection (%)	20/20	2/2	18/18	100%	20/20	20/20	4/4	16/16	3/3	17/17	8/8	12/12	100%	100%	100%	100%	100%	100%	100%	100%	100%

40 days vaccination	Control			F - I			F - II			F - III			BPL - I			BPL - II			BPL - III		
	All died	Lived	Died	All lived	Lived	Died	All lived	Lived	Died	All lived	Lived	Died	All lived	Lived	Died	All lived	Lived	Died	All lived	Lived	Died
Virus resolution (%)	20/20*	2/3	17/17	0/20	5/20	2/6	4/4	5/10	10/10	5/7	13/13	100%	66%	100%	0%	25%	12.5%	100%	50%	100%	71.4%
PCR detection (%)	20/20	3/3	17/17	100%	20/20	20/20	16/16	4/4	10/10	10/10	7/7	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Vaccine development : 1 - inactivated vaccine 2 - anti-viral IgY 3 - DNA vaccine

Production of antiviral egg yolk antibody (IgY)

Immunized hens by inactivated virus → Collect eggs to produce yolk powder

Vaccine development : 1 - inactivated vaccine 2 - anti-viral IgY 3 - DNA vaccine

Construction of DNA-based recombinant vaccines

1500 bp

M T-R GIV M T-R' GIV' M TGIV₁ TGIV₂ M

Plasmid maps for pGND3-EGFP-GIV and pGND3-TGIV-g-EGFP.

Iridoviridae (family)

Multiple sequence alignment (TCoffee) → Multiple linear epitope predictors (LPS, BEPPRED, LRTops, BCProbs, ABCPred) → Vaxig-Vi → Linear epitope length filter → Surface comparison → Physicochemical properties Check → Conserved/Exclusive LES → Biology experiment

Multiple structure prediction (Phyre2) → Multiple structure prediction

五種抗原表位預測系統的投票結果

