Integrated Multi-Trophic Aquaculture (IMTA): a responsible practice providing diversified seafood products while rendering biomitigative services

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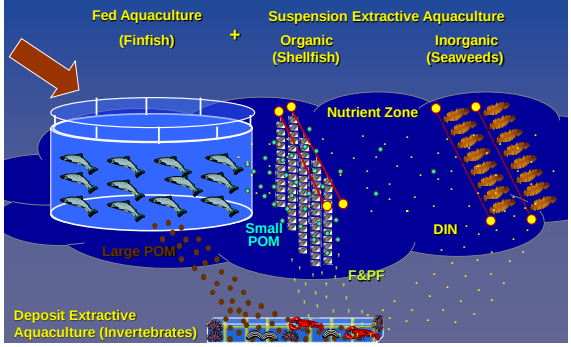
Integrated Multi-Trophic Aquaculture (IMTA)



Based on a very simple principle:

The solution to nutrification

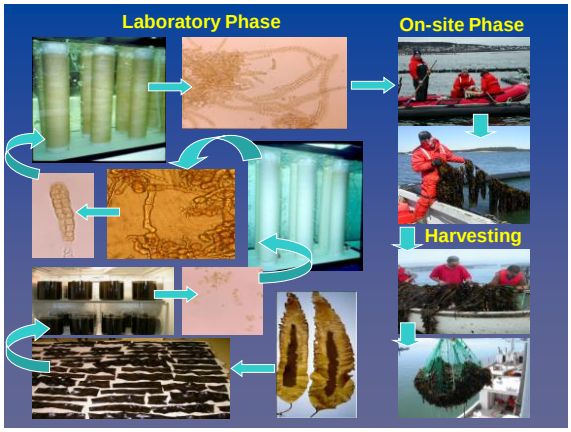
is not dilution...

but extraction and conversion

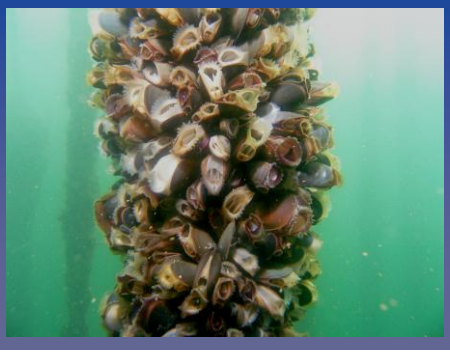
through diversification

Inorganic component of IMTA: seaweeds

- *Saccharina latissima*
  - previously *Laminaria saccharina*
  - *Saccharina* means sweet
  - similar to other *Saccharina* and *Laminaria* for the Oriental market
  - sold as "*kombu*"
- *Alaria esculenta*
  - *esculenta* means succulent
  - similar to *Undaria* for the Oriental market
  - sold as "*wakame*"



Organic component of IMTA: Mussels



. Meat yield of IMTA mussels: 56 %

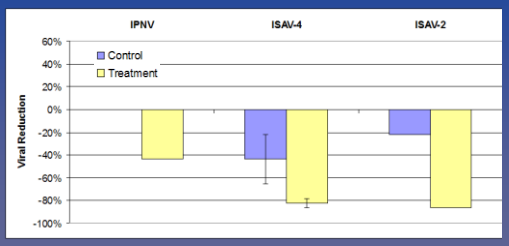
Meat yield of mussels you buy: 30-35 %

. More omega-3 fatty acids in IMTA mussels

(particularly DHA and EPA)

Viral Trials – 2008

Live – 24h



IPNV: Infectious Pancreatic Necrosis Virus

ISAV: Infectious Salmon Anaemia Virus

Food safety: monitoring of therapeutants with CFIA

SITE		DATE	TREATMENT	SPECIES	THERAPEUTANTS (µg/g) EMA	CYP	IVR	OTC	TC	CHL	ROM	TRI	FLOR
CFIA (Canada)					0.042	not available	not allowed	0.2	not available	not available	0.1	0.1	0.8
FDA (USA)													
EU Directives					0.1	0.05	not allowed	0.1	0.1	0.1	not allowed	0.05	1.0
Bocabec Bay		11/05/01		*L. saccharina*	ND	ND	ND	ND	ND	ND	ND	ND	
		21/06/01			ND	ND	ND	ND	ND	ND	ND	ND	
		20-28/06/01	EMA										
		27/07/01			ND	ND	ND	ND	ND	ND	ND	ND	
		11-17/08/01	EMA										
		07/09/01			ND	ND	ND	ND	ND	ND	ND	ND	
		20-30/09/01	OTC										
		15-23/10/01	EMA										
		19/10/01			ND	ND	ND	ND	ND	ND	ND	ND	
		07-16/11/01	OTC										
		12/12/01			ND	ND	ND	ND	ND	ND	ND	ND	
		02/02/02			ND	ND	ND	ND	ND	ND	ND	ND	
		04/04/02			ND	ND	ND	ND	ND	ND	ND	ND	
		27/06/02			ND	ND	ND	ND	ND	ND	ND	ND	
		19-25/07/02	EMA										
	control	30/07/02			ND	ND	ND	ND	ND	ND	ND	ND	
	cage				ND	ND	ND	ND	ND	ND	ND	ND	
	control	27/08/02			ND	ND	ND	ND	ND	ND	ND	ND	
	cage				ND	ND	ND	ND	ND	ND	ND	ND	
	control	15/10/02			ND	ND	ND	ND	ND	ND	ND	ND	
	cage				ND	ND	ND	ND	ND	ND	ND	ND	
	control	14/04/03			ND	ND	ND	ND	ND	ND	ND	ND	
	cage				ND	ND	ND	ND	ND	ND	ND	ND	
	control	20/05/03			ND	ND	ND	ND	[illegible]	ND	ND	ND	
	cage				ND	ND	ND	ND	[illegible]	ND	ND	ND	
	control	11/06/03			ND	ND	ND	ND	[illegible]	[illegible]	ND	ND	
	cage				ND	[illegible]	[illegible]	ND	[illegible]	[illegible]	ND	ND	
	control	03/07/03			ND	[illegible]	[illegible]	ND	ND	[illegible]	ND	ND	
	cage	07/07/03			ND	[illegible]	[illegible]	[illegible]	ND	ND	ND	ND	
Charlie Cove		21/04/04			ND	ND	ND	[illegible]	ND	ND	ND	ND	ND
J.D. Stewart		22/04/04			ND	ND	[illegible]	[illegible]	[illegible]	ND	ND	ND	ND
Frye Island		21/04/04			ND	ND	ND	[illegible]	[illegible]	ND	ND	ND	ND
Charlie Cove		26/05/04			ND	ND	ND	[illegible]	[illegible]	[illegible]	ND	ND	ND
J.D. Stewart		26/05/04			ND	ND	ND	ND	[illegible]	[illegible]	ND	ND	ND
Frye Island		26/05/04			ND	ND	ND	ND	ND	[illegible]	[illegible]	ND	ND
Charlie Cove		07/07/04			ND	ND	ND	ND	ND	[illegible]	[illegible]	ND	ND
J.D. Stewart		08/07/04			ND	ND	ND	ND	ND	[illegible]	[illegible]	ND	ND
Frye Island		08/07/04			ND	ND	ND	ND	ND	ND	[illegible]	ND	ND
Charlie Cove		26/07/04			ND	ND	ND	ND	ND	ND	[illegible]	ND	ND
J.D. Stewart		27/07/07			ND	ND	ND	ND	ND	ND	ND	ND	ND
Frye Island		27/07/04			ND	ND	ND	ND	ND	ND	ND	ND	ND
Charlie Cove		25/08/04			ND	ND	ND	ND	ND	ND	ND	ND	ND
J.D. Stewart		25/08/04			ND	ND	ND	ND	ND	ND	ND	ND	ND
Frye Island		25/08/04			ND	ND	ND	ND	ND	ND	ND	ND	ND
Charlie Cove		06/04/05		*L. saccharina*	ND	ND	ND	ND	ND	ND	ND	ND	ND
				A. esculenta	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aquaventure				*L. saccharina*	ND	ND	ND	ND	ND	ND	ND	ND	ND
				A. esculenta	ND	ND	ND	ND	ND	ND	ND	ND	ND
Charlie Cove		17/05/05		*L. saccharina*	ND	ND	ND	ND	ND	ND	ND	ND	ND
				A. esculenta	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aquaventure				*L. saccharina*	ND	ND	ND	ND	ND	ND	ND	ND	ND
				A. esculenta	ND	ND	ND	ND	ND	ND	ND	ND	ND
Charlie Cove		22/06/05		*L. saccharina*	ND	ND	ND	ND	ND	ND	ND	ND	ND
				A. esculenta	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aquaventure				*L. saccharina*	ND	ND	ND	ND	ND	ND	ND	ND	ND
				A. esculenta	ND	ND	ND	ND	ND	ND	ND	ND	ND
Charlie Cove		11/07/05		*L. saccharina*	ND	ND	ND	ND	ND	ND	ND	ND	ND
				A. esculenta	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aquaventure				*L. saccharina*	ND	ND	ND	ND	ND	ND	ND	ND	ND
				A. esculenta	ND	ND	ND	ND	ND	ND	ND	ND	ND

NOT DETECTABLE

Food safety: monitoring of heavy metals, arsenic and PCBs with CFIA

SITE		DATE	SPECIES	HEAVY METALS (µg/g) Hg	Al	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Se	Zn	ARSENIC (µg/g)	PCBs (µg/g)
CFIA (Canada)				0.5	n/a							0.5				2.0
FDA (USA)				1.0		4.0	13.0				80.0	1.7			86.0	2.0
EC (fish)				0.5-1.0		0.05-0.1						0.2-0.4				2.5
EC (bivalves)				0.5		1.0						1.0				
Bocabec Bay	control	30/07/02	*L. saccharina*	<0.01	9.10	0.09	0.07	0.62	14.27	0.70	0.04	0.08	0.29	2.19		<0.04
	cage			<0.01	6.30	0.15	0.03	0.93	9.38	1.19	0.08	0.09	0.11	2.91		<0.04
	control	15/10/02		<0.01	11.05	0.17	0.09	18.44	16.87	0.91	0.09	0.03	0.65	4.26	16.89	<0.04
	cage			<0.01	3.52	0.10	0.01	1.33	4.49	0.35	0.02	0.04	0.75	3.09		<0.04
	control	14/04/03		ND	1.54	0.13	0.04	0.59	4.68	0.48	0.03	0.07	0.02	5.98	6.98	<0.04
	cage			ND	2.94	0.12	0.06	0.21	8.49	0.40	0.04	0.02	0.01	5.03	8.22	<0.04
	control	20/05/03		ND	6.00	0.11	0.03	0.23	11.40	0.42	0.03	0.03	0.00	5.80	5.34	<0.04
	cage			0.01	7.38	0.04	0.03	0.21	14.29	0.47	0.04	0.13	0.05	3.56	1.00	<0.04
	control	11/06/03		0.01	10.86	0.06	0.06	0.57	15.17	0.63	0.09	0.07	0.06	2.38	1.44	<0.04
	cage			ND	12.93	0.06	0.03	0.30	15.17	0.80	0.07	0.03	0.06	2.73	1.56	<0.04
	control	03/07/03		ND	2.83	0.27	0.03	0.35	8.48	0.62	0.04	0.03	0.05	1.22	1.99	<0.04
	cage	07/07/03		0.01	[illegible]	0.11	0.03	0.35	4.81	0.92	0.04	0.03	ND	1.31	7.48	<0.04
Charlie Cove		21/04/04		<0.01	[illegible]	[illegible]	0.06	1.74	32.60	1.19	0.13	0.44	0.03	4.05		<0.04
J.D. Stewart		22/04/04		<0.01	[illegible]	[illegible]	[illegible]	[illegible]	22.30	1.08	0.07	0.03	0.02	3.22		<0.04
Frye Island		21/04/04		<0.01	14.30	0.16	[illegible]	0.83	[illegible]	1.11	0.08	0.04	0.04	2.60		<0.04
Charlie Cove		26/05/04		<0.01	35.40	0.14	0.05	0.83	[illegible]	0.77	[illegible]	0.04	0.03	1.99		<0.04
J.D. Stewart		26/05/04		<0.05	22.50	0.16	0.04	1.23	18.70	0.73	[illegible]	0.04	[illegible]	[illegible]		<0.04
Frye Island		26/05/04		<0.01	28.90	0.13	[illegible]	0.55	21.00	0.70	0.09	0.06	[illegible]	[illegible]		<0.04
Charlie Cove		07/07/04		<0.05	138.00	0.15	0.19	[illegible]	[illegible]	[illegible]	[illegible]	0.09	0.03	2.78		<0.04
J.D. Stewart		08/07/04		<0.01	90.20	0.12	0.13	0.46	[illegible]	[illegible]	[illegible]	[illegible]	0.03	1.76		<0.04
Frye Island		08/07/04		<0.01	89.40	0.13	0.12	1.45	60.50	1.39	0.12	[illegible]	[illegible]	2.34		<0.04
Charlie Cove		26/07/04		<0.01	162.00	0.22	0.21	0.74	104.00	2.15	0.18	0.13	[illegible]	3.21		<0.04
J.D. Stewart		27/07/07		<0.01	51.50	0.19	0.07	1.11	35.30	1.10	0.09	0.06	0.03	2.20		<0.04
Frye Island		27/07/04		<0.05	44.50	0.19	0.07	0.74	33.30	0.95	0.10	0.07	0.03	2.47		<0.04
Charlie Cove		25/08/04		<0.01	28.20	0.23	0.05	0.45	21.30	0.99	0.07	0.07	0.03	2.04		<0.04
J.D. Stewart		25/08/04		<0.05	42.70	0.21	0,07	0.65	31.90	1.41	0.12	0.12	0.07	2.69		<0.04
Frye Island		25/08/04		<0.01	72.00	0.18	0.18	0.99	49.30	1.61	0.14	0.24	0.02	3.13		<0.04
Charlie Cove		17/05/05	*L. saccharina*	0.09	156.00	0.35	0.30	0.79	120.00	3.78	0.22	0.23	0.02	7.19		<0.001
			A. esculenta	<0.05	532.00	0.31	0.84	1.07	405.00	8.01	0.62	0.53	0.13	6.26		<0.001
Aquaventure			*L. saccharina*	<0.05	68.60	0.17	0.17	0.59	56.00	2.24	0.15	0.37	0.04	3.51		<0.001
			A. esculenta	0.06	427.00	0.30	0.69	0.84	318.00	7.36	0.51	0.44	0.12	6.24		<0.001
Charlie Cove		11/07/05	*L. saccharina*	<0.05	39.90	0.33	0.10	0.56	40.08	1.85	0.14	0.12	0.03	3.56		<0.001
			A. esculenta	<0.05	318.00	0.41	0.56	1.32	266.00	6.36	0.58	0.34	0.13	7.06		<0.001
Aquaventure			*L. saccharina*	<0.05	108.00	0.31	0.24	0.58	92.40	2.89	0.22	0.18	0.03	3.70		<0.001
			A. esculenta	<0.05	138.00	0.34	0.28	1.06	127.00	4.07	0.37	0.34	0.07	5.62		<0.001

Below CFIA, FDA and EC regulatory limits

Food safety: monitoring of pesticides with CFIA

SITE		DATE	SPECIES	PESTICIDES (µg/g) Aldrin	a-BHC	b-BHC	d-BHC	Lindane	a-Chlordane	g-Chlordane	4,4'-DDD	4,4'-DDT	Dieldrin	Endrin	Heptachlor	Heptachlor epoxide	Oxy-chlordane	4,4'-DDE	Mirex	HCB
CFIA (Canada)				0.1	0.1	0.1	0.1	0.1	0.1	0.1	5.0	5.0	0.1	0.1	0.1	0.1	0.1	5.0	0.1	0.1
FDA (USA)				0.3					0.3			5.0	0.3	0.3	0.3	0.3		5.0	0.1	
EC (fish)																				
EC (bivalves)																				
Bocabec	control	30/07/02	*L. saccharina*	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
Bay	cage			<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.010	<0.007	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
	control	14/04/03		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
	cage			<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
	control	20/05/03		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
	cage			<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
	control	11/06/03		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
	cage			<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
	control	03/07/03		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
	cage	07/07/03		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
Charlie Cove		21/04/04		<0.002	<0.002	[illegible]	[illegible]	[illegible]	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
J.D. Stewart		22/04/04		<0.002	<0.002	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
Frye Island		21/04/04		<0.002	<0.002	<0.002	<0.002	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
Charlie Cove		26/05/04		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
J.D. Stewart		26/05/04		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<0.007	<0.004	<0.002
Frye Island		26/05/04		<0.002	<0.002	<0.002	<0.002	[illegible]	[illegible]	[illegible]	<0.003	<0.003	<0.002	<0.002	[illegible]	[illegible]	[illegible]	[illegible]	<0.004	<0.002
Charlie Cove		07/07/04		<0.002	<0.002	<0.002	<0.002	<0.002	[illegible]	[illegible]	[illegible]	[illegible]	<0.002	<0.002	<0.002	[illegible]	[illegible]	[illegible]	<0.004	<0.002
J.D. Stewart		08/07/04		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<0.002	<0.002	<0.007	<0.004	<0.002
Frye Island		08/07/04		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<0.002	<0.007	<0.004	<0.002
Charlie Cove		26/07/04		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	[illegible]	[illegible]	<0.002	<0.007	<0.004	<0.002
J.D. Stewart		27/07/07		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
Frye Island		27/07/04		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
Charlie Cove		25/08/04		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
J.D. Stewart		25/08/04		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
Frye Island		25/08/04		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.003	<0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.007	<0.004	<0.002
Charlie Cove		17/05/05	*L. saccharina*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
			A. esculenta	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aquaventure			*L. saccharina*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
			A. esculenta	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Charlie Cove		11/07/05	*L. saccharina*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
			A. esculenta	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Aquaventure			*L. saccharina*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
			A. esculenta	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Below CFIA, FDA and EC regulatory limits

Profitability – Net Present Value (NPV in US$)

NPV calculated for a 10 year period at discounted rates of 5 and 10%

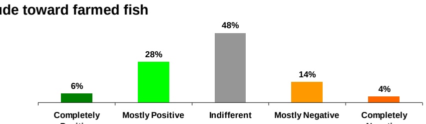
3 scenarios:

- optimistic (20% probability): 5 successful harvests (11% mortality rate)
- intermediate (40% probability): 4 successful harvests (11% mortality rate) 1 harvest (70% mortality rate)
- pessimistic (40% probability): 4 successful harvests (11% mortality rate) 1 harvest completely destroyed (disease or winter chill)

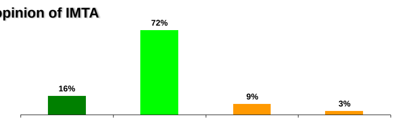
Operation	NPV	Optimistic	Intermediate	Pessimistic
Salmon monoculture	5%	8,146,477	2,664,112	50,848
IMTA	5%	8,906,435	3,296,037	674,580
Salmon monoculture	10%	6,885,181	2,391,135	- 228,345
IMTA	10%	7,508,913	3,014,866	403,579

New York consumers are generally indifferent in their opinion of farmed fish and overwhelmingly support an IMTA approach

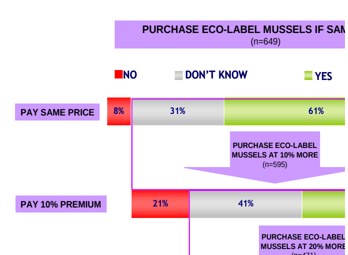
Current attitude toward farmed fish



Consumer opinion of IMTA



Differentiated, eco-labelled, IMTA mussels will need to be priced competitively with other mussels in the market, with some potential for a 10% price premium, given an adequate promotion of their benefits and value



>>> better traceability
>>> healthy products
>>> gaining consumer trust and societal and political license to operate
>>> commanding premium market price

Conclusions (at this stage): the R&D&C continuum

Current R&D supports the development of IMTA to C (commercialization) to move aquaculture to a new ERA (Ecosystem Responsible Aquaculture) as a promising practice for:

- **environmental sustainability** (biomitigation),
- **economic stability** (product diversification and risk reduction), and
- **societal acceptability** (improved support for the industry and its differentiated, safe products).

Recognizing and valuing the services rendered by the extractive components of IMTA

>>> Nutrient trading credits (NTC)

In SW New Brunswick:
- 96 finfish sites
- if 2/3 of the sites are active each year >>> 64 sites
- if 8 seaweed rafts/site >>> 512 seaweed rafts

Costs of removing nitrogen:
- sewage treatment facilities: between US$3-38 to remove 1 kg N (depending on technologies and labour costs)
- municipality of Lysekil (Sweden): paying US$9.1/kg N removed to the mussel farm Nordic Shell Produktion AB

Nutrient trading credits (NTC):

0.3% N, US$10/kg >> **US$306,432** US$30/kg >> **US$919,296**

0.5% N, US$10/kg >> **US$510,720** US$30/kg >> **US$1,532,160**

+ phosphorus trading credits? (note: P is the next element we will be short of)

+ carbon trading credits? (note: only US$25-30/tonne C)

+ the same should be calculated for the organic extractive component of IMTA.

With IMTA, some of the externalities of fed monoculture can be internalized.
>>> Increasing the overall sustainability, profitability and resilience of aquaculture farms.

Recognizing and accounting for the economic value of the environmental/societal services rendered by extractive species is needed to evaluate the true value of these components of IMTA.

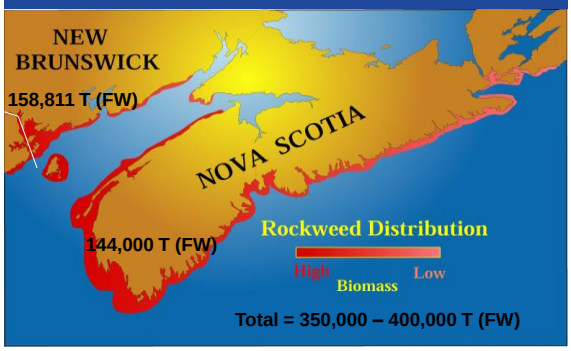
>>> Creating economic incentives to encourage aquaculturists to further develop and implement IMTA systems.

>>> Increasing the societal acceptability of aquaculture by the general public.

But, aquaculture never operates alone…

Rockweed (*Ascophyllum nodosum*) dominates the intertidal zone in the Bay of Fundy.

Rockweed (*Ascophyllum nodosum*) distribution in the Maritimes



In SW New Brunswick:

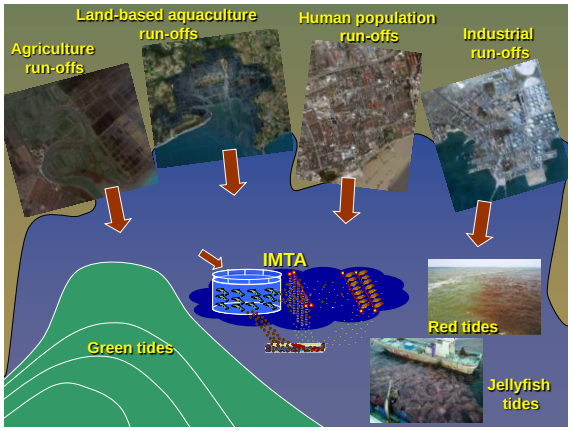
158,811 T (FW)

NTC

0.25% N, US$10/kg >> US$3.97 M

0.25% N, US$30/kg >> US$11.91 M

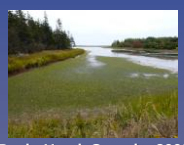
China



Ulva green tides in different places around the world

Qingdao, China, 2008

St. Michel en Grève, France, 2009



Basin Head, Canada, 2008

A negative media photo opportunity, or a reminder of the significant role of seaweeds in coastal processes and the biomitigative services they render?

Green tide of *Ulva prolifera* in Qingdao, just before the 2008 Olympic Games sailing competition

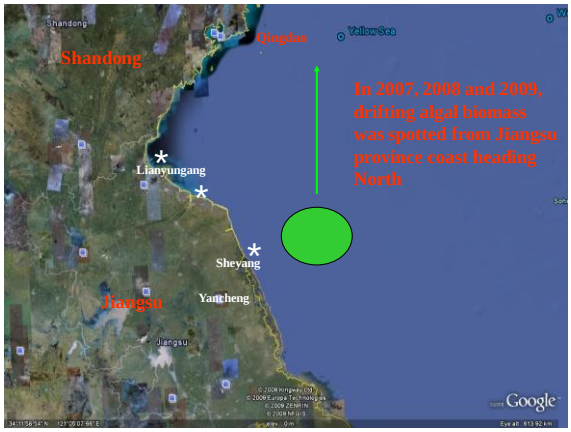
(but also in 2007 and in 2009)

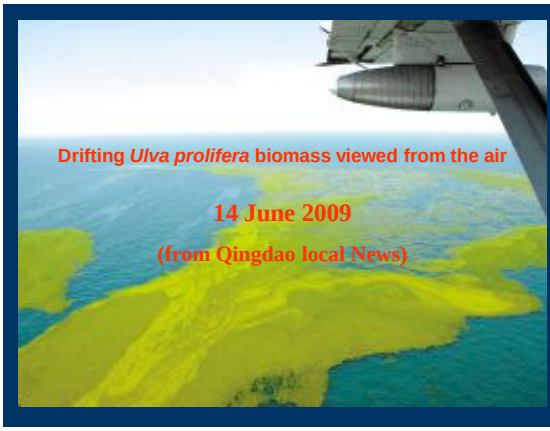
Removal of at least 1,000,000 tonnes (FW) of *Ulva prolifera* in a few weeks (approximately 2,000,000 tonnes (FW) went to the bottom).

0.3% N, US$10/kg >> removal of 3,000 T nitrogen — NTC (US$30.0 M)

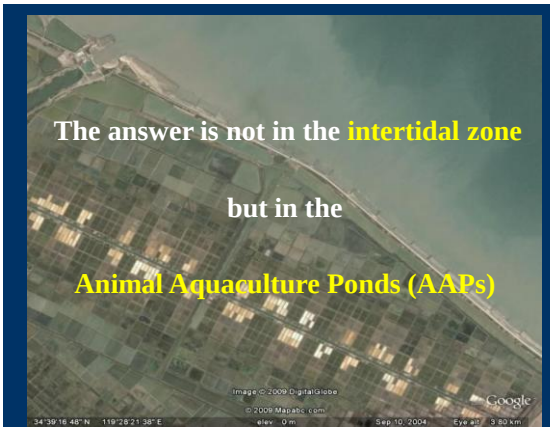
0.5% N, US$30/kg >> removal of 5,000 T nitrogen — (US$150.0 M)







Where are, then, the original niches of the green tide located?



Organic fertilizer

↓

Chlorella sp.

↓

Rotifers

↓

Juvenile river crab *Eriocheir sinensis*

↓

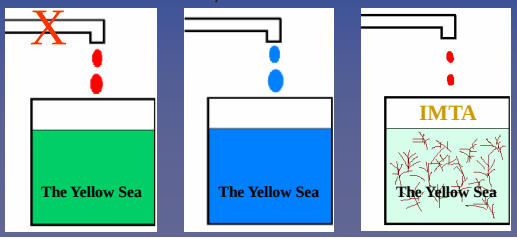
High levels of NH_4^+ and PO_4^{3-}

Is there a strategy for a solution?

Not many nutrient removal options >>> **algal scrubbers** is one of them.

The problem: *Ulva prolifera* = **unwanted growing** nuisance species of limited commercial value.

The solution: create a competition for nutrients by **intentionally cultivating** species, which not only carry on the biomitigation, but also have commercial value, where *Ulva* enters the coastal environment to control its proliferation.



Conclusions

Nutrient extractive aquaculture is a **viable** ecological engineering option. Seaweed farms, while producing a multiple-use biomass, also render **biomitigative services.**

True recognition of the environmental/economic/societal services of **extractive crops** would create strong incentives to develop sustainable **Marine Agronomy** practices, such as IMTA, in which seaweeds and invertebrates should also be **traded for nutrient and carbon credits, CO_2 sequestration, oxygen provision, and coastal eutrophication reduction.**

Only when these services are properly recognized and valued, will we be able to establish **the true value** of the extractive components of IMTA so that **biomitigative solutions** become an integral part of **coastal regulatory and management frameworks.**

Beyond the biological, environmental, economic, technological, engineering and regulatory issues, the basic question will be that of societal acceptance.

Are we ready for the zoning of some portions of the oceans for large multi-purpose parks such as aquaculture / wind / biofuel farms?

If the "NIMBY" and the "BANANA" attitudes continue to prevail, especially in the Western World, then we will not be able to secure our seafood and energy in an ecosystem responsible manner, despite all the rhetoric we can hear today…