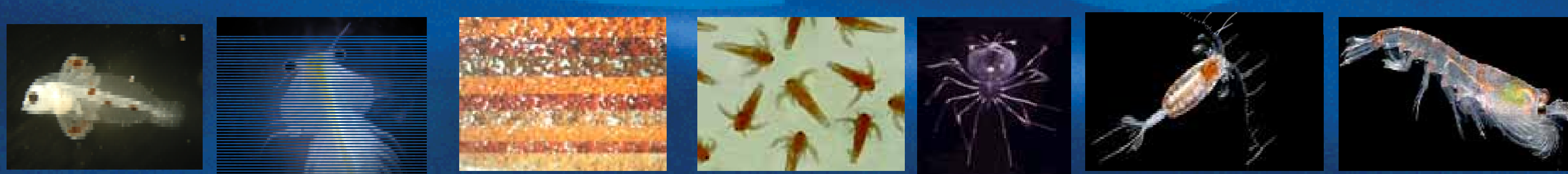
Marine fish larvae microdiets – Beyond nutrition

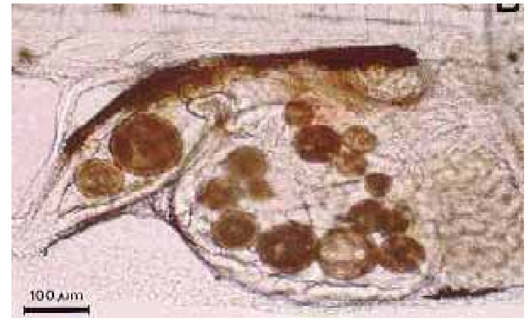
Sagiv Kolkovski, John Curnow and Justin King



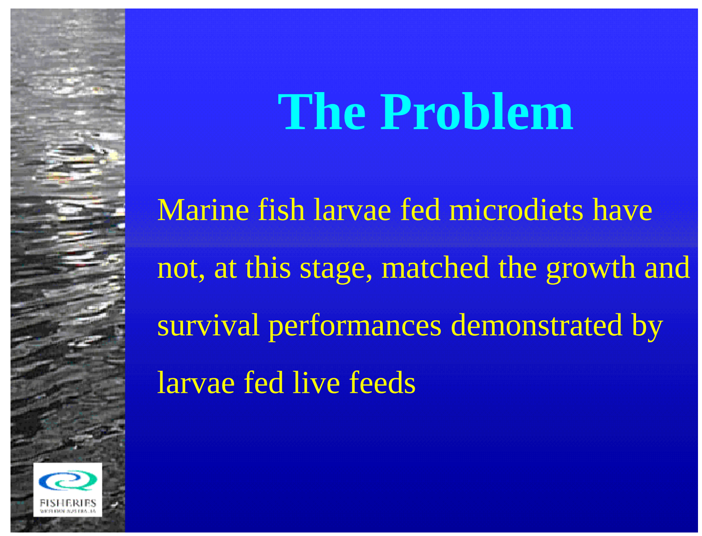
Aquaculture and Aquatic Health
Government of Western Australia
Department of Fisheries

Fish for the future

The Problem

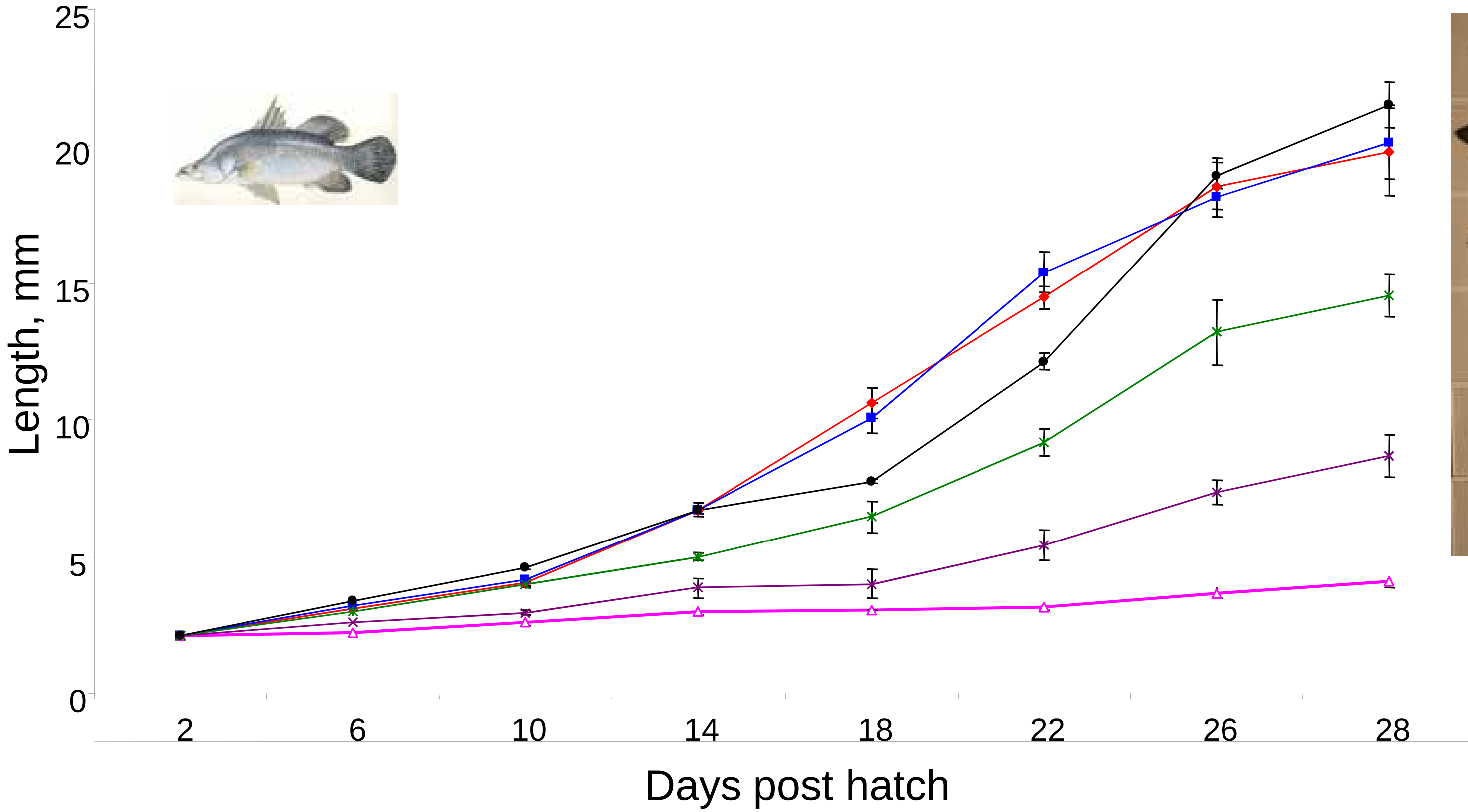


Marine fish larvae fed microdiets have not, at this stage, matched the growth and survival performances demonstrated by larvae fed live feeds



From Larvi 2001

Effect of various feeding protocols on Barramundi larvae



G — Diet (Gemma micro) only

G3 — Diet (Gemma micro) day 2, rotifers days 2-4)

G7 — Diet (Gemma micro) day 4, rotifers days 2-8)

G12 — Diet (Gemma micro) day 9. Rotifers days 2-13

G12A — Diet (Gemma micro) day 6, rotifers days 2-13, *Artemia* days 12-20

P12A — Diet (Proton) day 6, rotifers days 2-13, *Artemia* days 12-20

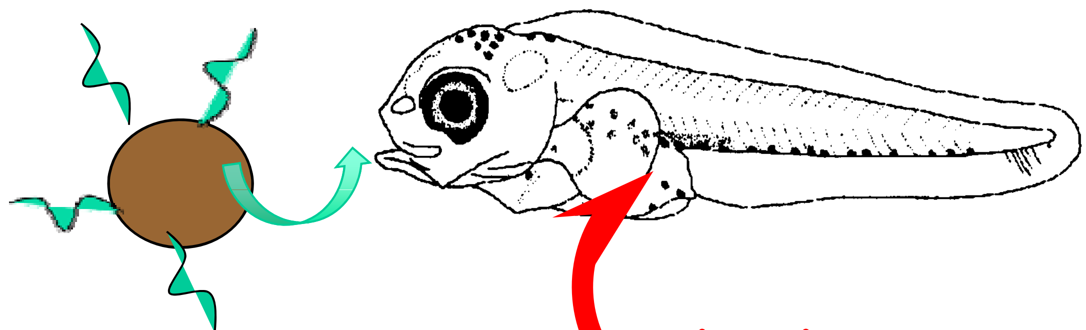
Weaning protocols of difference fish larvae species

Fish species	Weaning protocol	Findings	Authors
Pikeperch Sander *lucioperca* (freshwater)	Weaning at hatch, 12 or 19 days post hatch (dph)	Best growth, survival and lowest deformities but high cannibalism at post-hatch weaning.	Kestemont et al. 2007
Solea senegalese	Weaning protocols	Artemia –fed larvae grew threefold less then fish fed an inert diet. Sudden weaning and co-feeding resulted in larger fish than late weaning.	Engrola et al. 2007
Sea bass *Dicentrarchus labrax*	Weaning period, 15, 20 and 25 dph	Lowest growth and survival rates when weaned at 15 dph. Highest at 25 dph	Suzer et al. 2007
Atlantic cod	Weaning protocols, 0%, 50% and 100% Artemia replacement with MD	Highest survival and growth achieved in treatments with Artemia (100% and 50%)	Fletcher et al. 2007
Atlantic cod	Larvae rearing protocols (review)	Weaning achieved at 22 with reduced growth. Higher growth achieved with late weaning (30 dph)	Rosenlund and Halldorsson, 2007
Fat snook *Centropomus parallelus*	Weaning period	Successfully weaned at 35 dph but higher growth achieved at 40 dph weaning	Alves et al. 2005
Common sole Solea sloea	Weaning diets comparison	Weaning at 30 DAH, one diet achieved comparable survival to Artemia treatment and better growth	Palazzi et al. 2006
Tongue sole *Cynoglossus semilaevis*	Weaning protocols	Co-feeding regimes preformed similar or better then Artemia regime	Chang et al. 2006
Dourado *Salminus brasiliensis*	Weaning time	Early weaning (3, 5 dph) resulted in lower survival although length and weight was not affected	Vega-Orellana
Pacu *Piaractus mesopotamicus*	Weaning protocols	Artemia –fed larvae showed the higest growth compared to diet-fed larvae.	Tesser et al. 2005
Sturgeon *Acipenser sturio*	Weaning periods	Long weaning (21 days) resulted in better growth and survival then short weaning (3 days)	Williot et al. 2005
Barramundi *Lates calcarifer*	Weaning protocols	Complete replacement of Artemia was achieved. However better survival achieved when small amount of Artemia was added.	Curnow et al 2006a, b
Dover sole *Solea solea*	Diet type and weaning time	Early weaning (42 dph) resulted at higher survival. Late weaning resulted at higher growth.	Rueda-Jasso et al. 2005

Factors affecting food particle utilisation

Physical factors
size
shape
movement
ingredients and binders
moisture

Window of opportunity

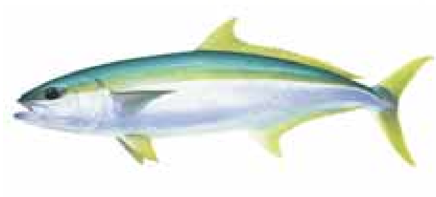


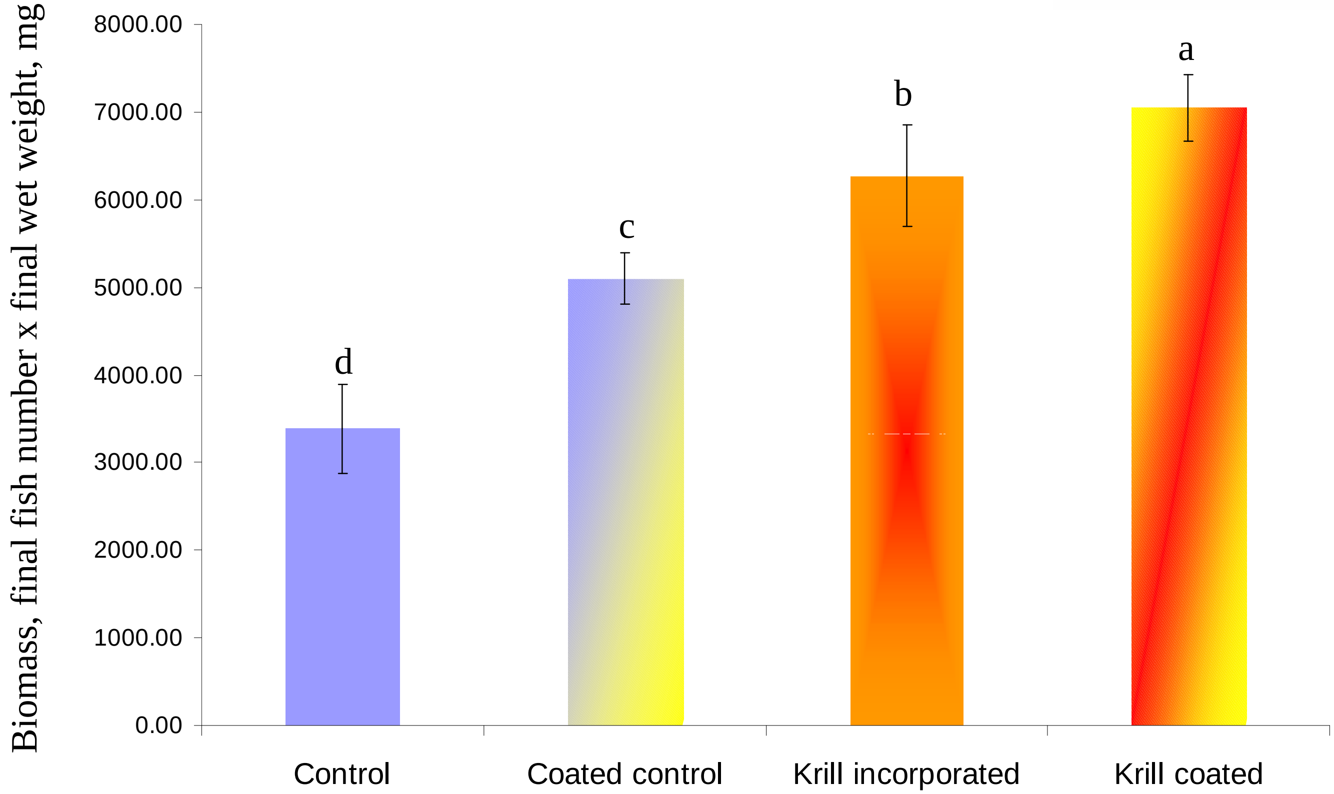
Chemical factors
Leaching ('smell')
Ingredients ('taste')

Acceptance or rejection

Digestive system
digestive enzymes
peristaltic movements
digestive tract development
acid secretion, bile salts

Effect of krill hydrolysate on Yellowtail kingfish *seriola lalandi* larvae growth and survival





Kolkovski, Curnow, and King, 2006

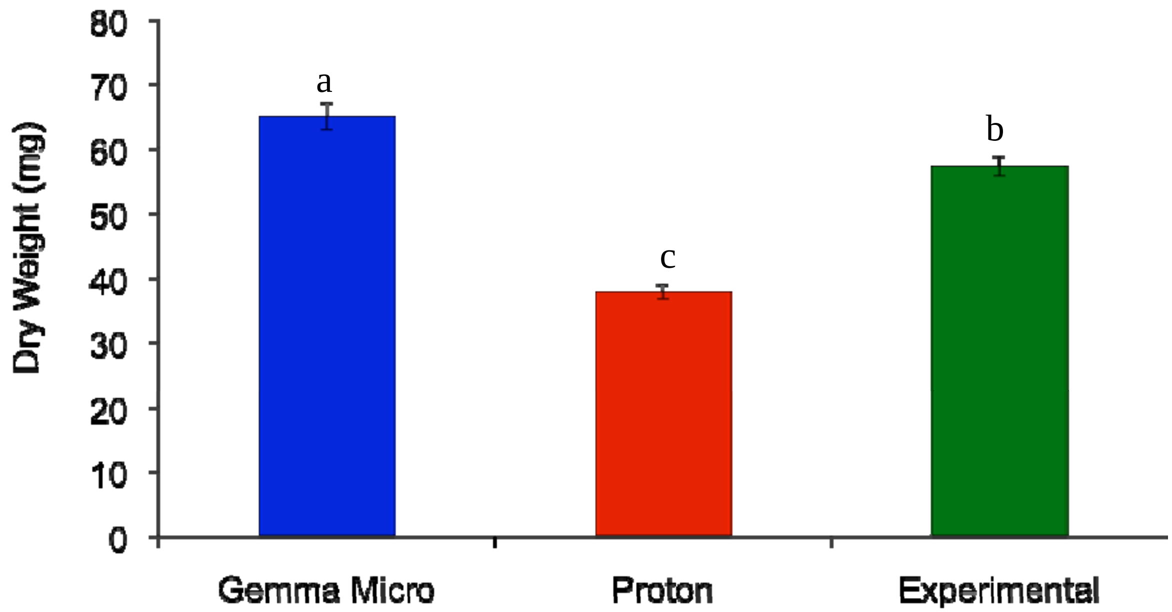
Liquid krill hydrolysate was mixed with ethanol and sprayed over the microdiet

Aquatic organisms (hydrolysate or extract) used as feed attractants

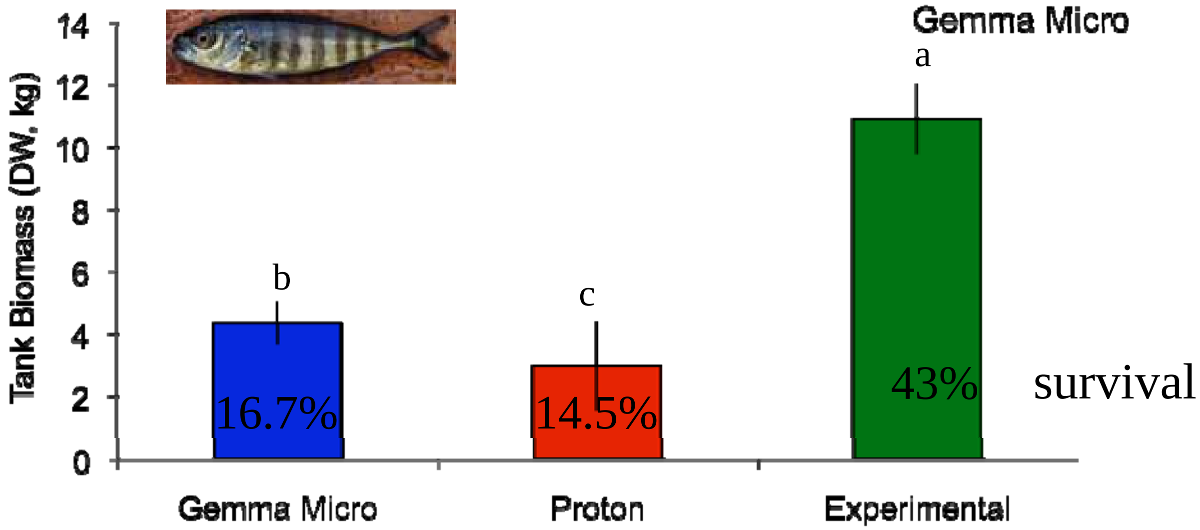
Organism	Tested on	Reference
Balanus nauplii	Herring *Clupea harengus*	Dempsey, 1978
Tubifex blood worm	Tilapia	Iwai, 1980
Short necked clam *Tapes japonica*	Japanees eel *Anguilla japonica*	Hashimoto et al., 1968
Cod *Gadus morhua*	Hermit crab *Petrochirus diogenes*	Hazlett, 1971
Cod *Gadus morhua*	Glass ell *Anguilla anguilla*	Kamstra and Heinsbroek, 1991
Abalone	Spiny lobster *Panulirus interruptus*	Zimmer-Faust et al., 1984
Dungeness crab *Cancer magister*	Little neck clam *Protethace staminea*	Pearson et al., 1979
Pink shrimp *Penaeus duorarum*	Spiny lobster *Panulirus argus*	Reeder and Ache, 1980
Marine polychaete *Perinereis brevicirrus*	Red sea Bream *Chrysophrys major*	Fuke et al., 1981
Shrimps	Rainbow trout *Oncorhynchus mykiss* and Atlantic salmon *Salmo salar*	Mearns et al., 1987
Krill *Euphausia pacifica*	Yellow perch *Perca flavescens*, Walleye *Stizostedion vitreum*, Lake whitfish *Coregonus clupeaformis*,	Kolkovski et al., 2000, Kolkovski, 2001
Krill *Euphausia pacifica*	Barramndi, *Lates calcarifer*	Curnow et al., 2006
Krill *Euphausia pacifica*	American lobster *Homarus americanus*	Floreto et al., 2001
Krill *Euphausia pacifica*	Black tiger shrimp *P. Monodon*	Smith et al., 2005
Mussel *Mytilus edulis*	Gilthead sea beam *Sparus aurata*	Tandler et al., 1982
Fish (non specific)	Black tiger shrimp *P. Monodon* Largemouth bass *Micropterus salmoides*	Smith et al., 2005 De Oliveira and Cyrino, 2004

Commercial / experiment microdiets effects on growth and survival of yellowtail kingfish larvae

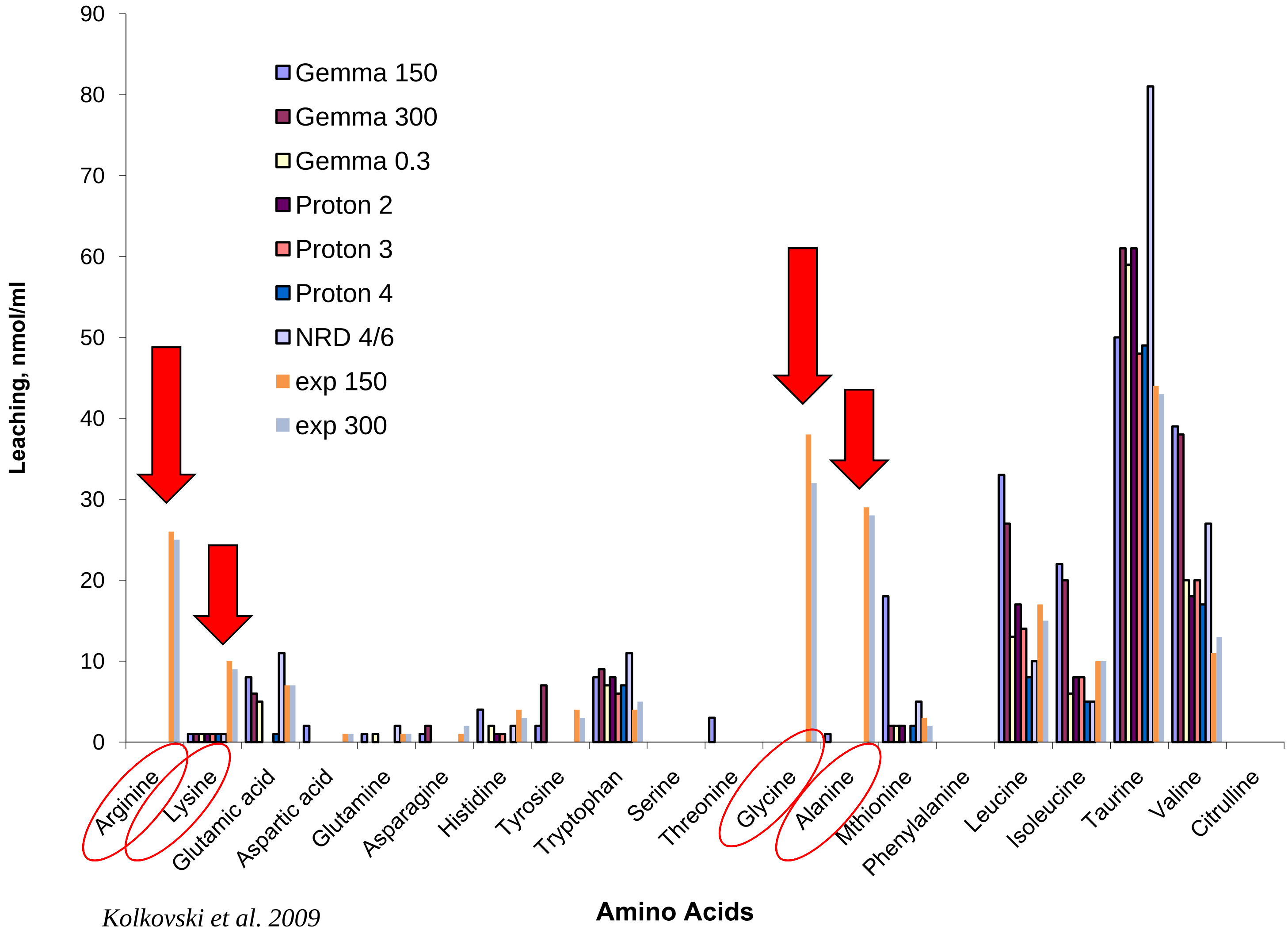
Weaning period: 20 dph – 37 dph



Kolkovski et al. 2009



Amino acid leaching after 8 min immersion in sea water

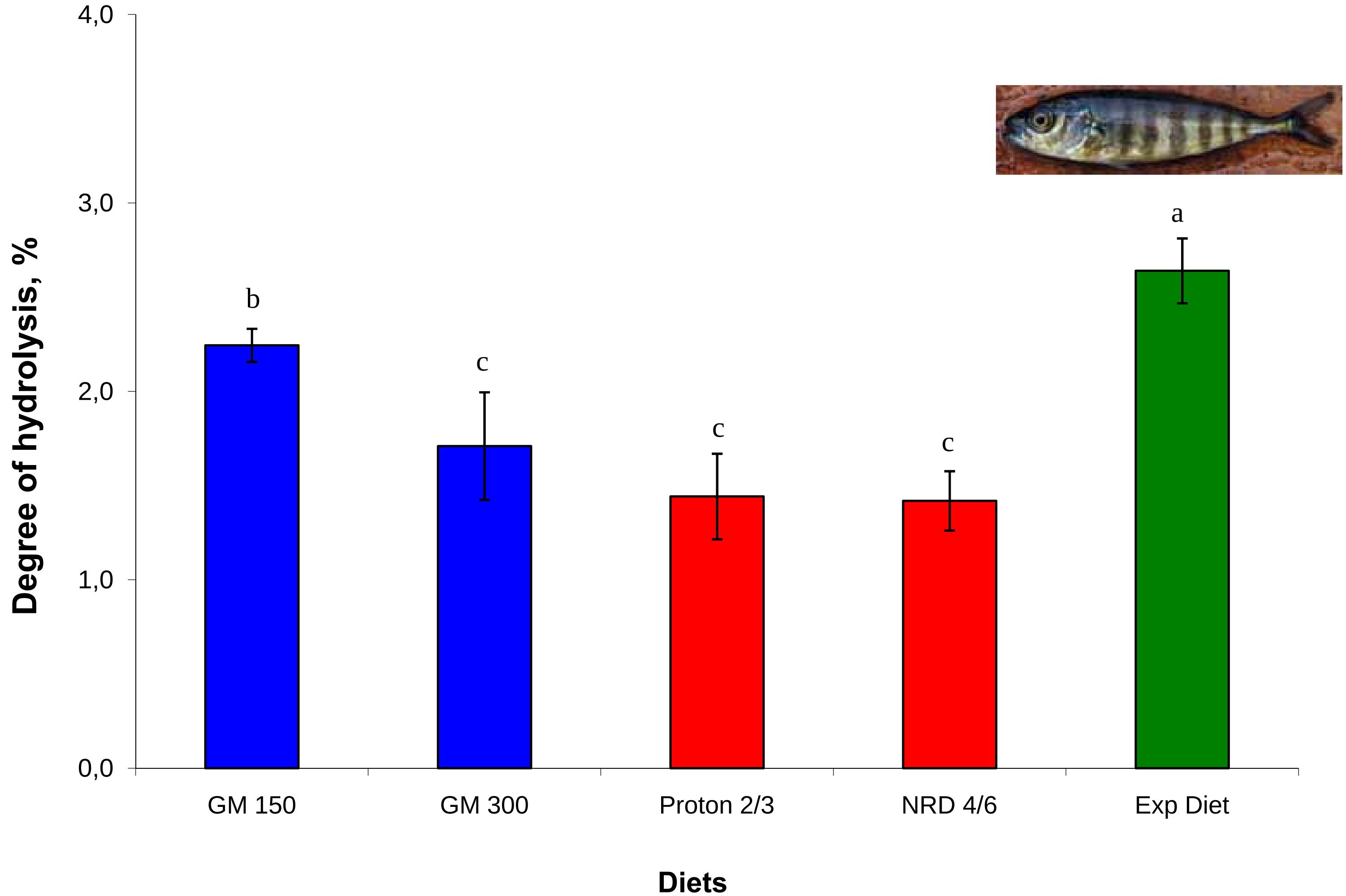


Kolkovski et al. 2009

Amino Acids and other metabolites used as feed attractants in marine organisms

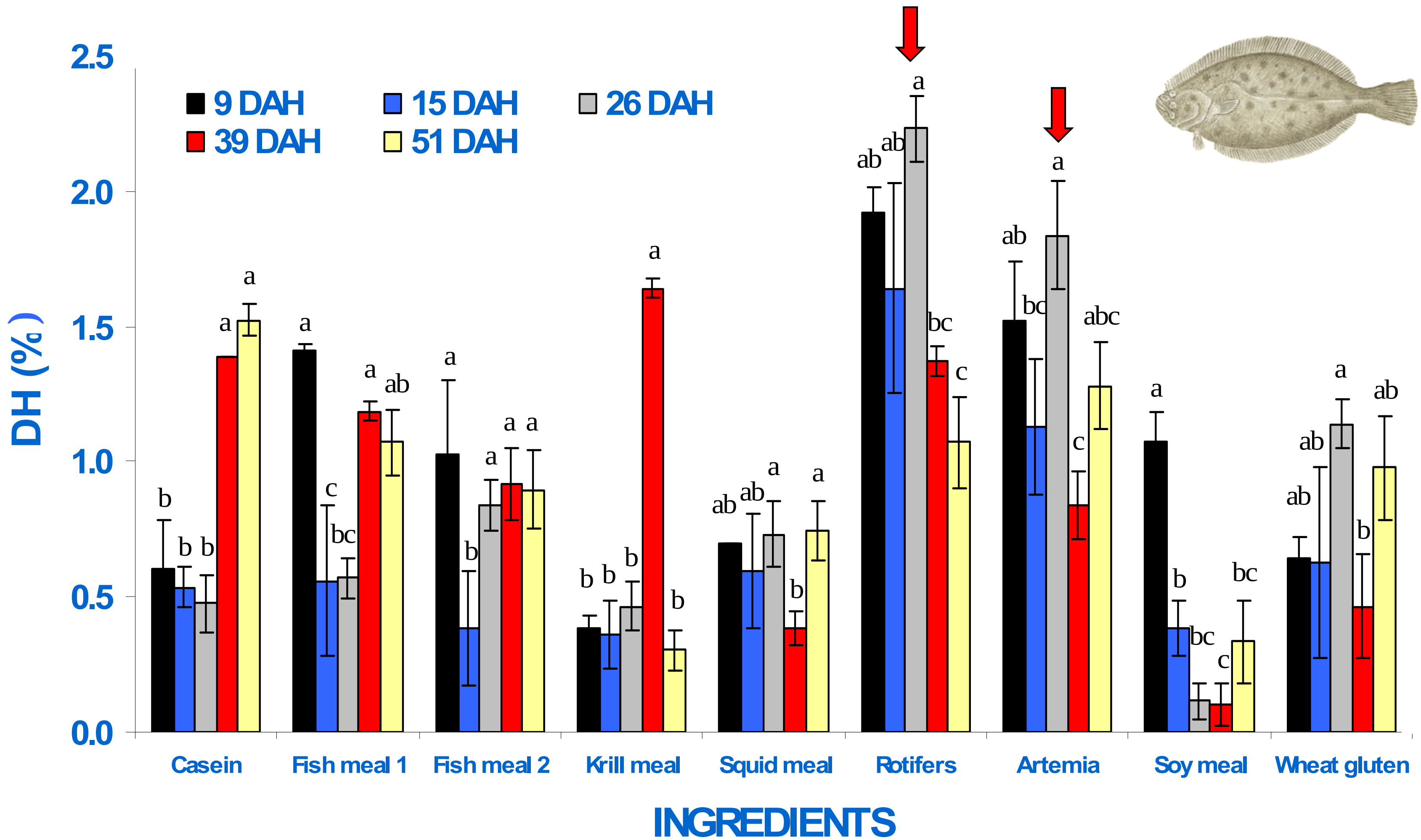
Rainbow trout *Salmo gairdineri*	Mixture of L-amino acids	Adron and Mackie, 1978
Atlantic salmon *Salmo salar*	Glycine	Hughes, 1990
Sea bass *Dicentrarchus labrax*	Mixture of L-amino acids	Mackie and Mitchell, 1982
Pig fish *Orthopristis chrysopterus*	Glycine, Betaine	Carr et al. 1977, 1978
Red sea bream *Chrysophrys major*	Glycine, Betaine Glycine, Alanine, Lysine Valine, Glutamic acid and Arginine	Goh and Tamura, 1980 Fuke et al., 1981 Ina and Matsui, 1980
Gilthead sea bream *Sparus aurata*	Glycine, Betaine, Alanine, Arginine	Kolkovski et al., 1997
Turbot *Scophthalmus maximus*	Inosine and IMP	Mackie and Adron, 1978
Dover sole *Solea solea*	Glycine, Betaine Glycine, Inosine, Betaine	Mackie et al., 1980 Metaillet et al., 1983
Puffer *Fugu pardalis*	Glycine, Betaine	Ohsugi et al., 1978
Japanese eel *Anguilla japonica*	Glycine, Arginine, Alanine, Proline	Yoshii et al., 1979
Cod *Gadus morhua*	Arginine	Doving et al., 1994
Herring *Clupea herangus*	Glycine, Proline	Damsey, 1984
Glass eel *Anguilla anguilla*	Glycine, Arginine, Alanine, Proline Alanine, Glycine, Histidine , Proline	Mackie and Mitchell, 1983 Kamstra and Heinsbroek, 1991
Lobster *Homarus Americanus*	Glutamate, Betaine, Taurine, Ammonium chloride	Corotto et al., 1992
Western Atlantic ghost crab *Ocypode quadrata*	Butanoic acid, Carboxylic acid, Trehalose, carbohydrates, Homarine, Asparagine	Trott and Robertson, 1984
Freshwater prawn *Macrobrachium rosenbergii*	Taurine, Glycine, Trimethylamine, Betaine	Harpaz et al., 1987
Abalone *Haliotis discus*	Mixture of L-amino acid and lecithin	Harada et al., 1987
Gibel carp *Carassius auratus gibelio*	Glycine, Lysine, Methionine, Phenylalanine, Betaine	Xue and Cui, 2001

Degree of hydrolysis (DH) of tested microdiets



DH was determined using pH-STAT technique utilizing yellowtail kingfish digestive enzymes *Lazo et al. 2009*

Changes in degree of ingredients hydrolysis (DH) in California halibut *Paralichthys californicus* larvae

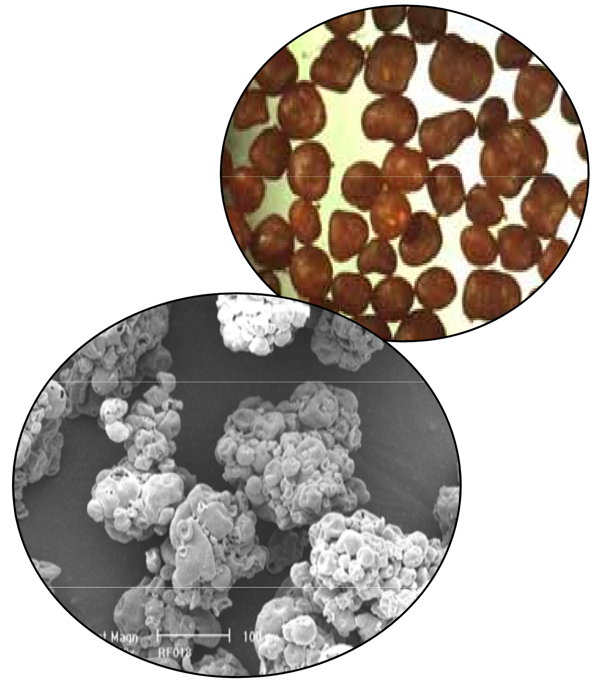


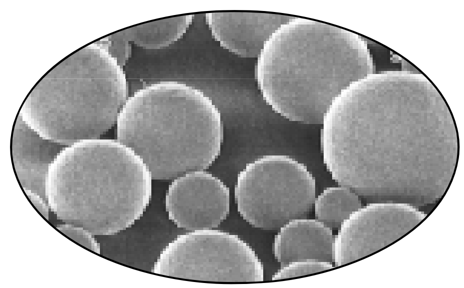
Lazo, 2008, Adapted from Martinez-Montaño et al., 2006

Microdiet Types

Microbound

Marumerizing

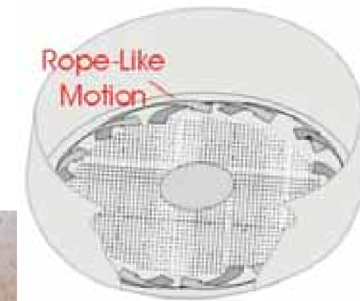




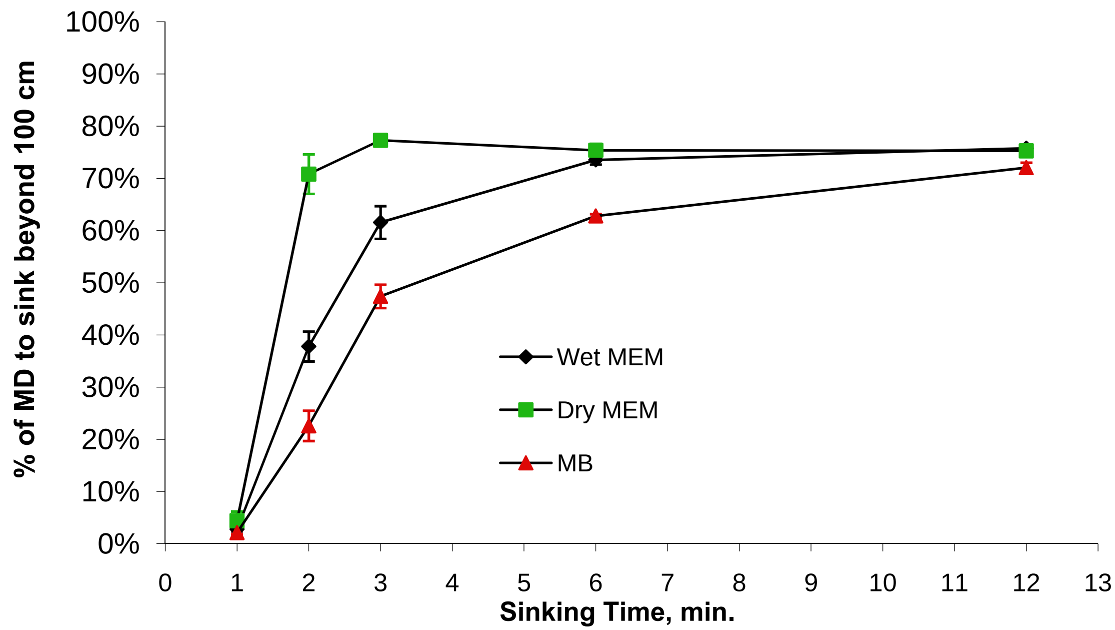
Microencapsulated

Marumerization

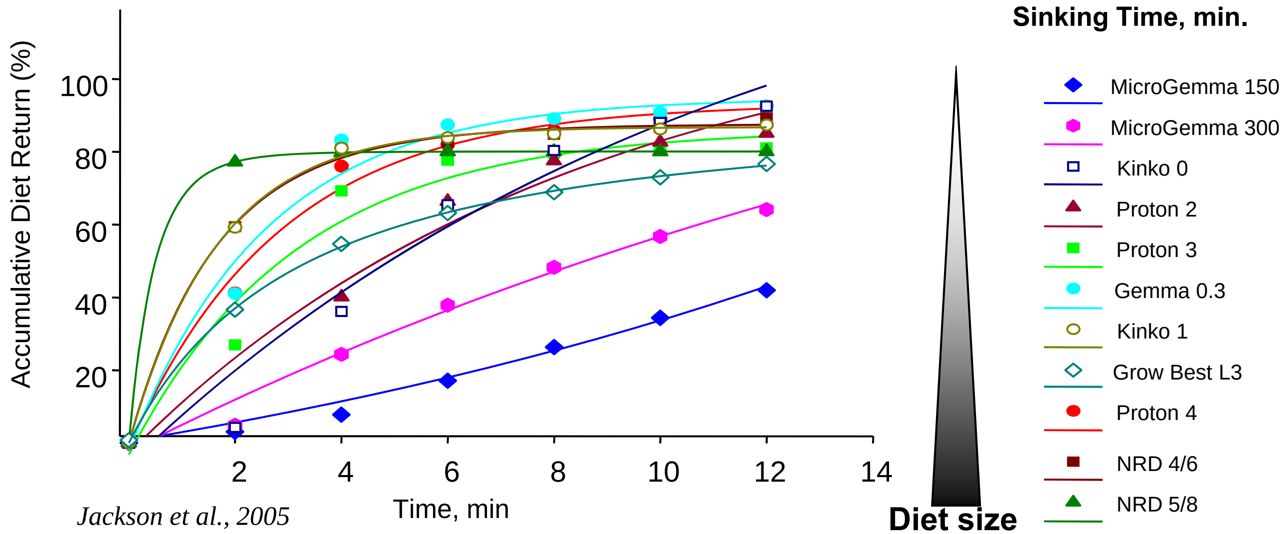
Rounded or spherical granules of extrudates



Sinking rates



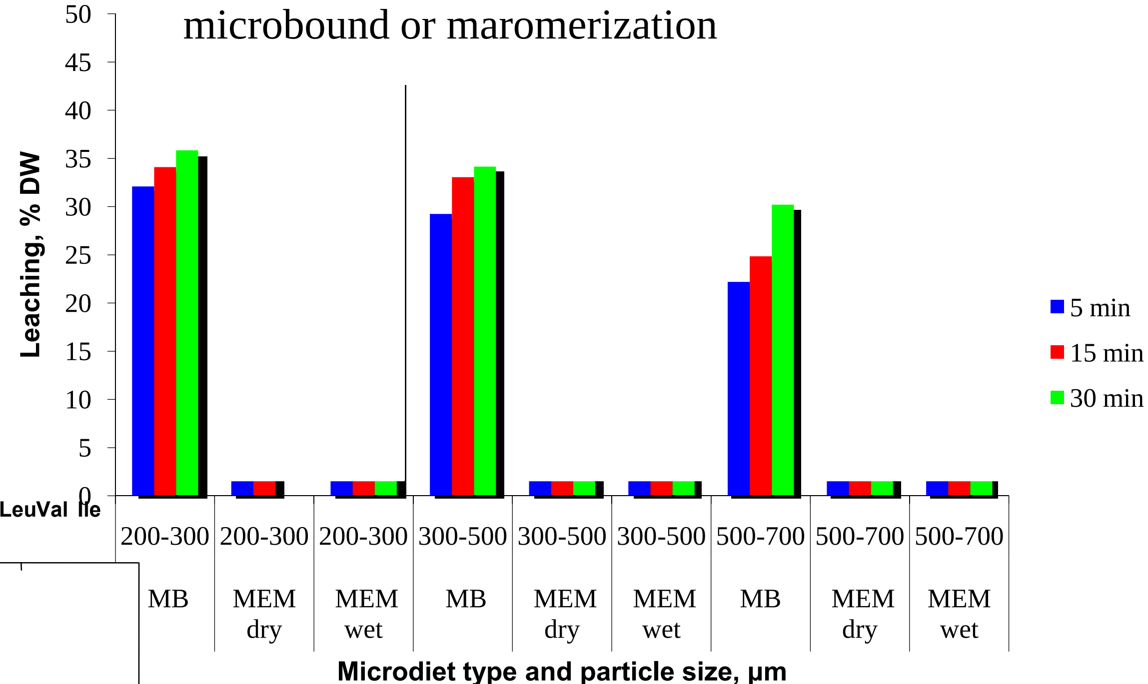
Kolkovski et al. 2009



Jackson et al., 2005

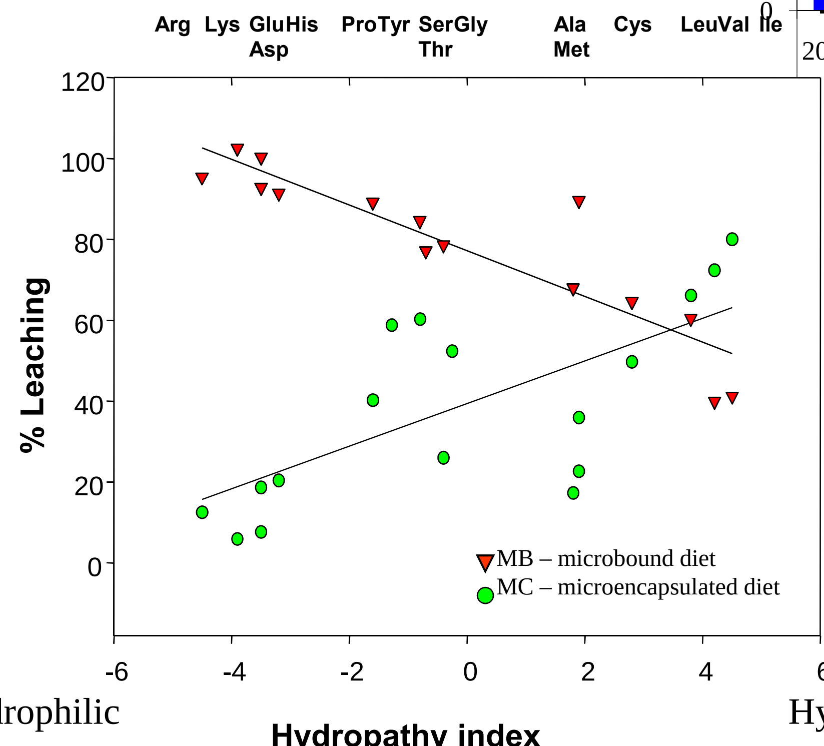
Leaching rates

Leaching rates of microdiet manufactured by microbound or maromerization



Kolkovski et al., 2009.

Amino acid leaching profile from microbound or microencupsolated microdiets



Yufera et al., 2002.

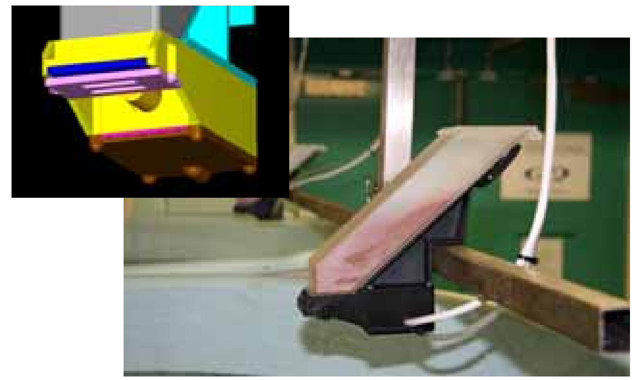
Hydrophilic Hydrophobic

Microdiet Feeding Systems requirements

- ✓ Very small amount of microdiet
- ✓ Very short feeding intervals
- ✓ Changeable intervals during the day (higher feeding intervals in the morning etc.)
- ✓ Even distribution with no clumps
- ✓ Larger distribution
- ✓ Accommodate different particle sizes

Feeding system

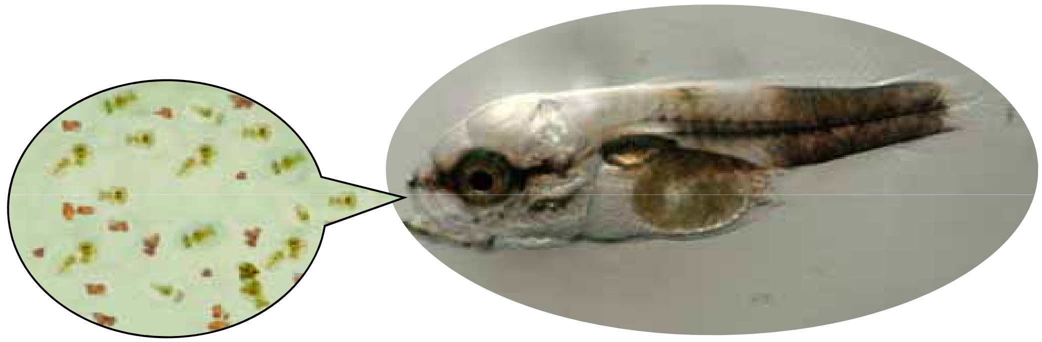
Very few systems designed specifically for microdiet !



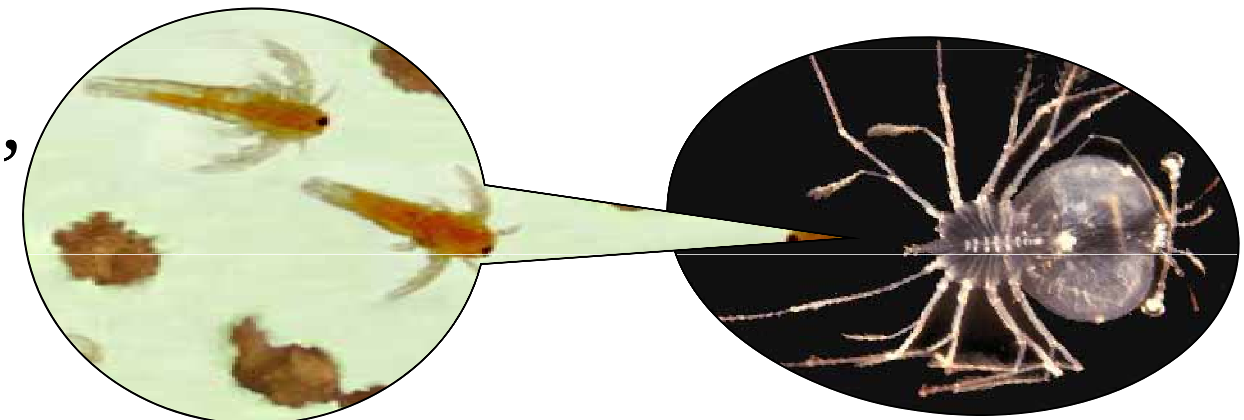
"Spider"
Delivery system
Raunes hatchery, Norway

Mode of Larval Feeding

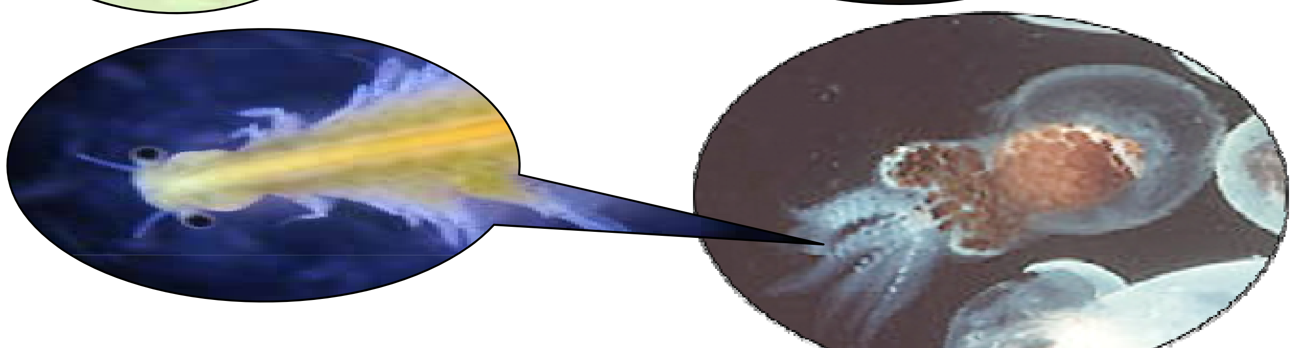
‘Gulpers’
Fish larvae



‘Nibblers’
Rock lobster
Phyllosoma

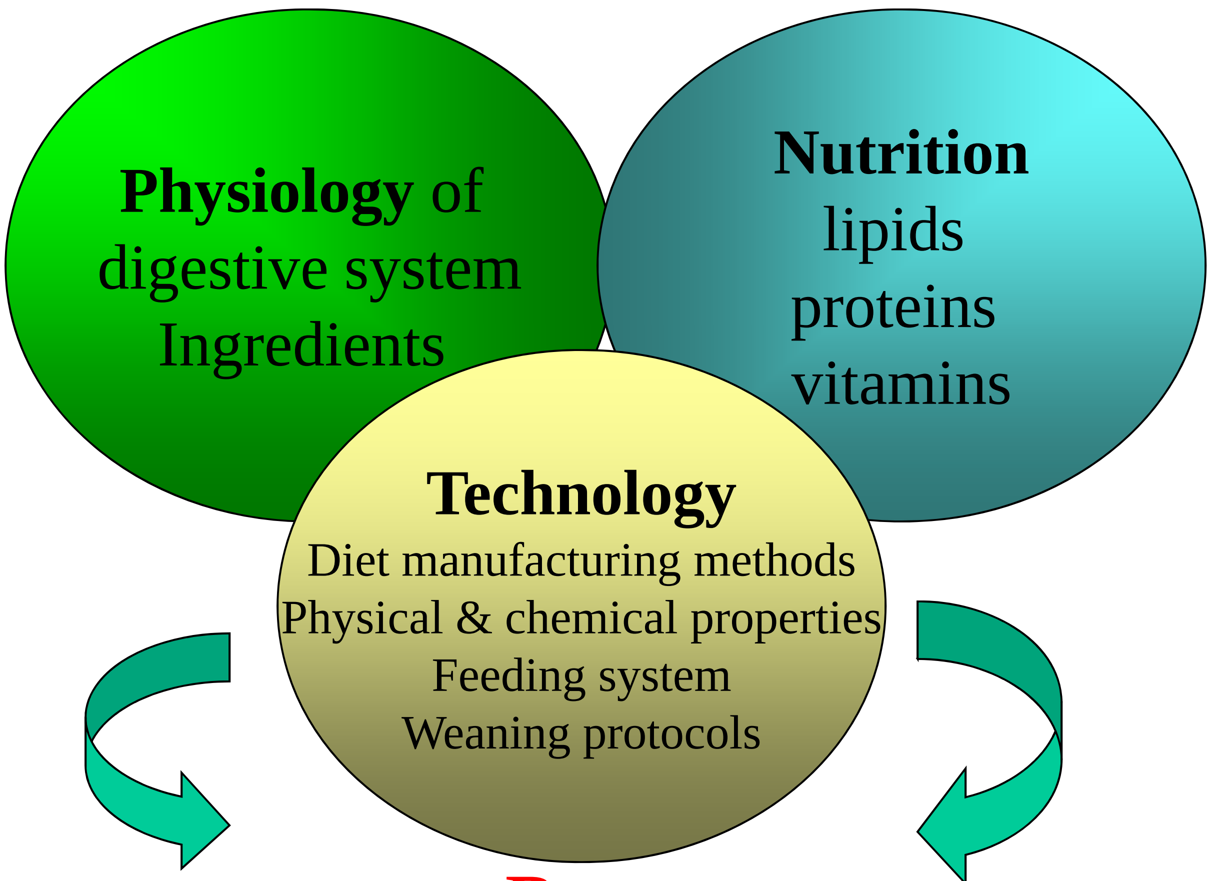


‘Suckers’
Octopus
paralarvae



The 'Holistic' Approach

Integrative approach is needed to be taken in the development of microdiets for fish larvae



Better

Ingestion, Digestion, Assimilation


Thank you