

New Marine Feed Resources

Investigation of Under-utilized Marine Resources for Atlantic halibut



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Halibut Aquaculture and Nutrition

- Proper nutrition key aspect in health and growth of farmed fish
- Diets for juvenile halibut formulated to optimize growing time, health, and product quality
- Nutrition requirements of halibut are unique and must be consistently met to avoid health problems and mortality



Nutritional Requirements of Halibut

- Protein

- Source of energy and amino acids
- 45-60% protein supplied in diet
- 10 essential amino acids (EAA)



- Lipid

- Source of energy and essential fatty acids (EFA)
- 15-30% lipid supplied in diet
- Omega-3 and -6 cannot be synthesized by marine fish, must be supplied in diet (DHA, EPA)

Fatty Acid Desaturation and Elongation

Diet

↓

18:2n-6 (eg. Soy oil)

↓ $\Delta 6$ desaturase

18:3n-6

↓ elongase

20:3n-6

↓ $\Delta 5$ desaturase

20:4n-6 ARA (Animal fat)

Diet

↓

18:3n-3 (eg. Flaxseed oil)

↓ $\Delta 6$ desaturase

18:4n-3

↓ elongase

20:4n-3

↓ $\Delta 5$ desaturase

20:5n-3 EPA (Fish oil)

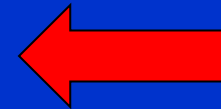
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22:5n-3

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24:5n-3

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24:4n-3

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22:6n-3 DHA (Fish Oil)



Commercial Feeds

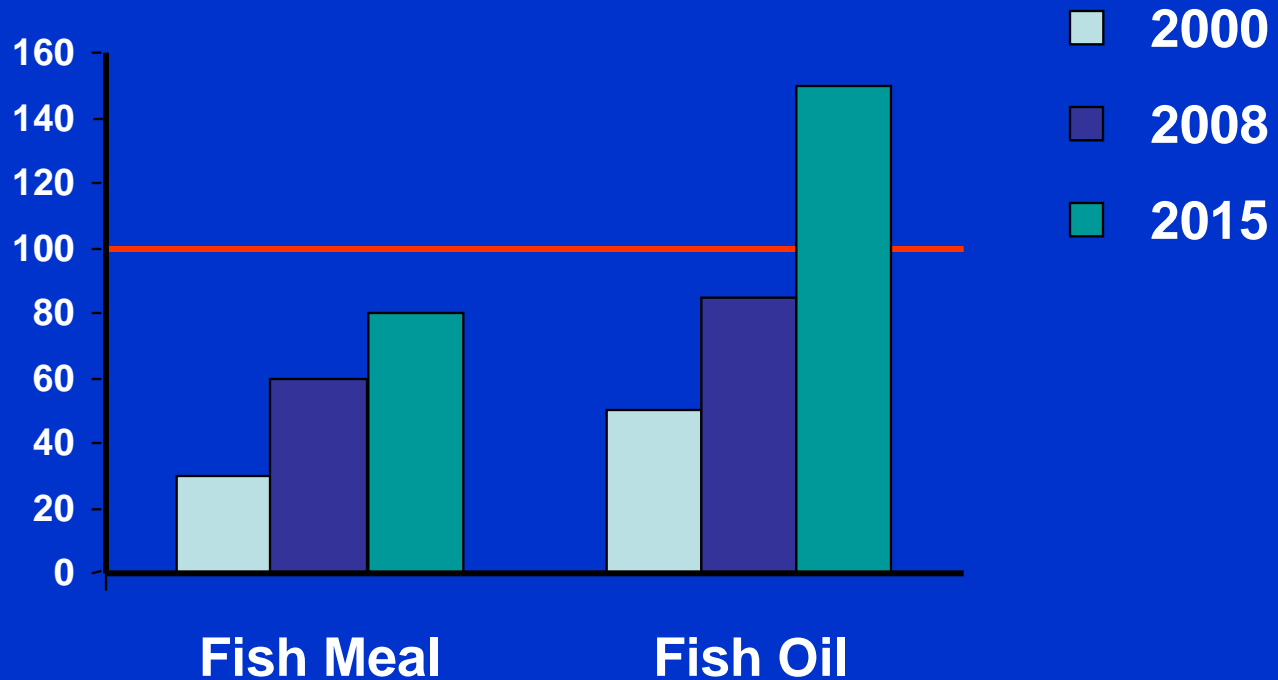
- Main dietary source of protein and lipid: fish meal and oil
- Anchovy, herring, mackerel, menhaden capture fisheries



Limiting Factors

- Global demand for seafood- 110 million tons of fish produced for food ... 47% produced by aquaculture (FAO 2008)
- Over half of wild stocks assessed are deemed fully exploited
- Production of fish meal and oil cannot sustain aquaculture industry in future

Fish Meal and Oil Usage for Aquaculture (% global production)



Main Challenges

- Reduce fish meal and oil in commercial feed by using alternative sources of lipid and protein
- Nutrient sources must meet marine finfish species requirements for essential fatty acids (EFA) and essential amino acids (EAA)
- Guarantee good fish growth and health
- Produce quality product to meet consumer demand

Alternative Protein & Lipid Sources

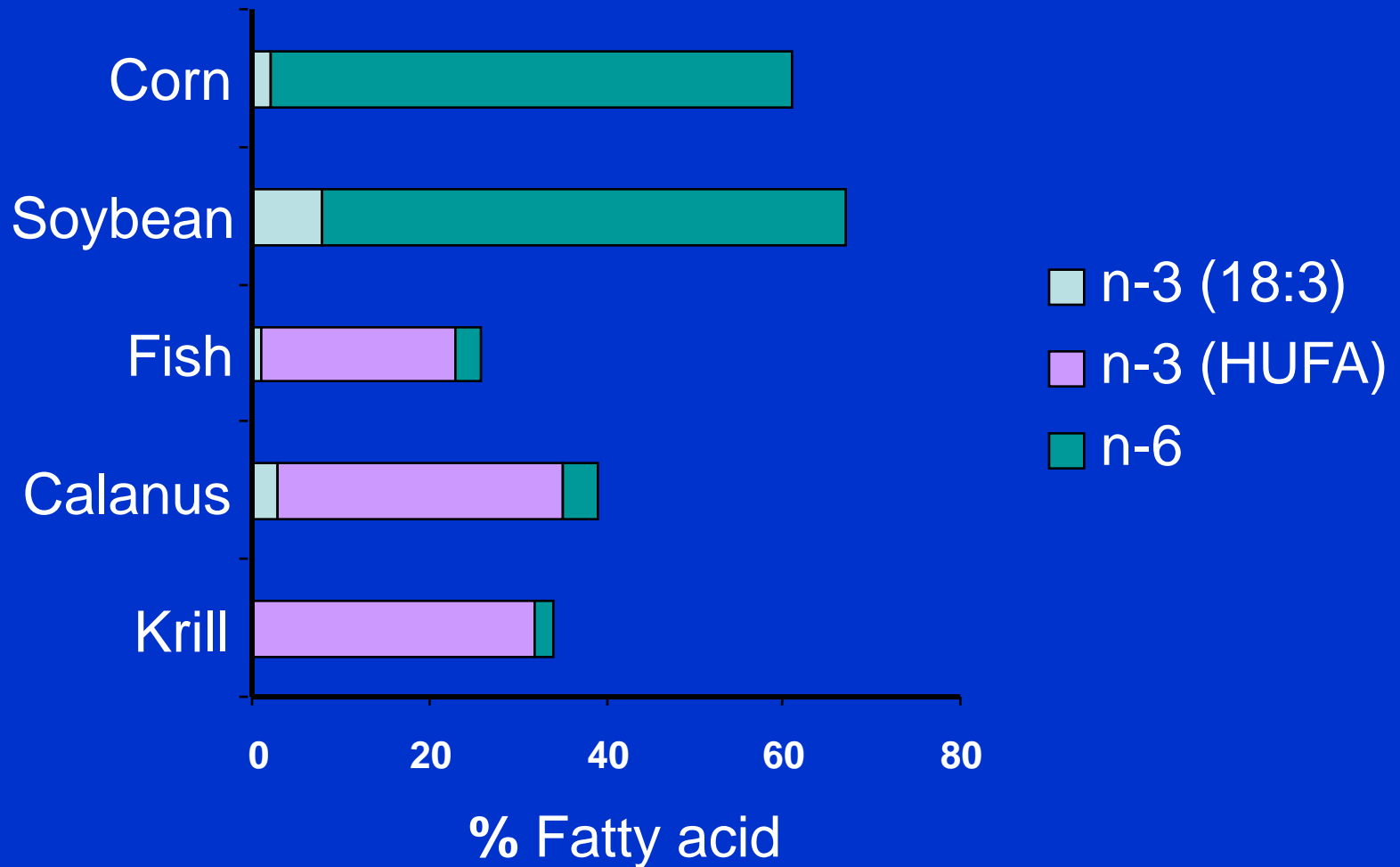
- Plant protein and lipid?
 - Protein: lacking essential amino acids (EAA), presence of antinutritional factors
 - Lipid: high levels of omega 6, but low levels of Omega 3, and low levels of essential fatty acids (EFA), lacking EPA and DHA
 - Cannot fully replace fish meal



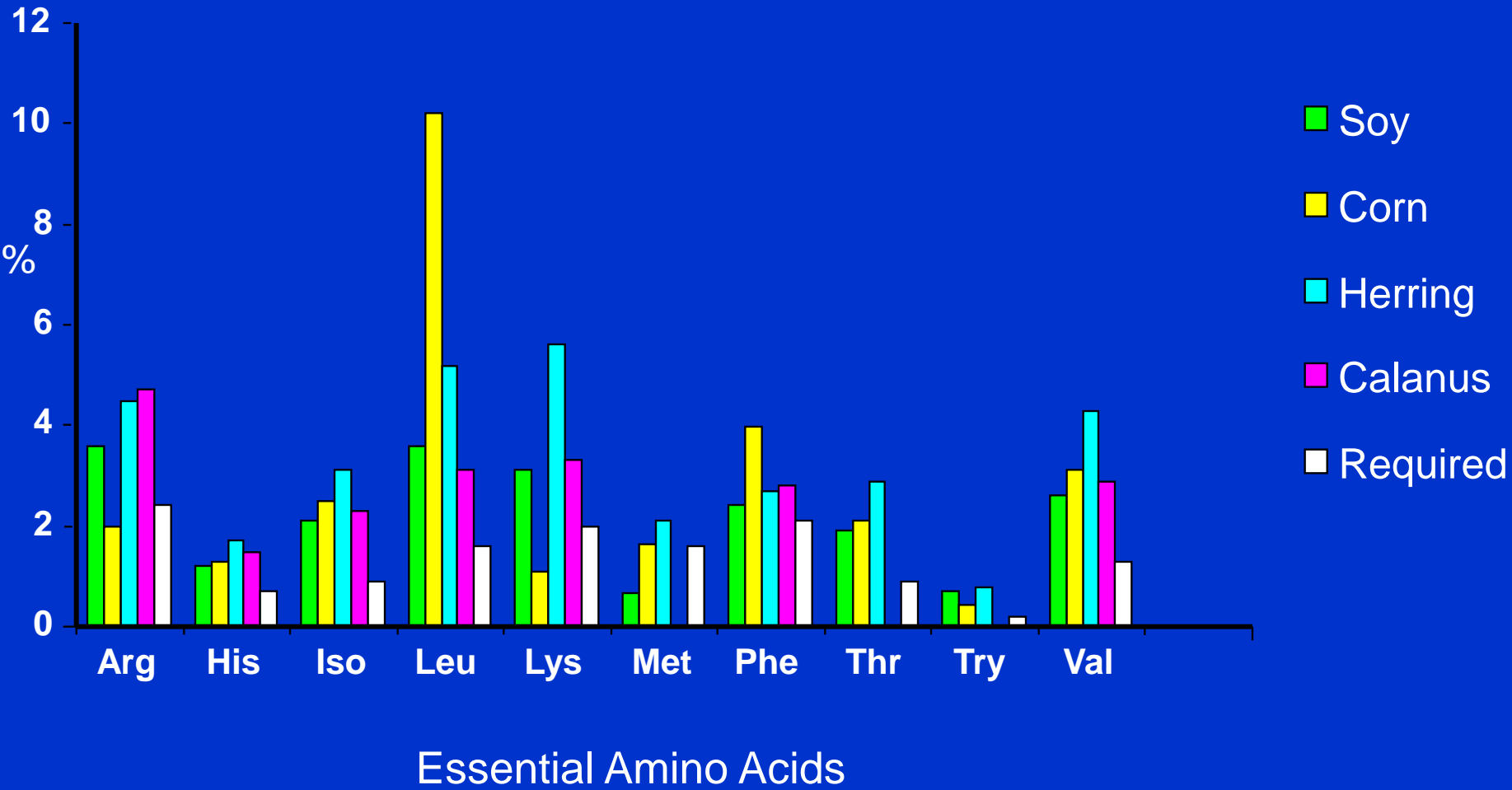
Marine Resources

- Untapped resource, abundant
- Lower trophic levels of the marine ecosystem: could contribute a significant supply of EFAs for human consumption
- Natural prey item for marine fish larvae
- Complete EFA and EAA profiles

Distribution of Fatty Acids in Vegetable Oils vs. Marine Oils



Amino Acid Profiles of Vegetable Protein vs. Marine Protein



Zooplankton Facts

- Antarctic krill- Biomass 117-379 MMT
- *Calanus* copepod- 48 MMT
- *Calanus* unique feature: ability to store >75% body weight as lipid
- Krill ingredient positive for human health- currently used in pharmaceutical industry
- Possible to process into ground meals and oils that can be included as a protein and/or lipid source



Nutritional Composition

	Krill	Copepod
Moisture %	4.50	8.23
Ash %	13.0	10.7
Protein %	60.3	50.5
Lipid %	15.7	26.9
Energy MJ/kg	22.7	24.9

Applications

- Feed attractant
 - Produces high feeding response
 - Added to low-palatable feeds (i.e. plant-based meals, medicated diets)
 - Contains low molecular weight soluble compounds: nucleosides, amino acids (proline, glycine, glucosamine)

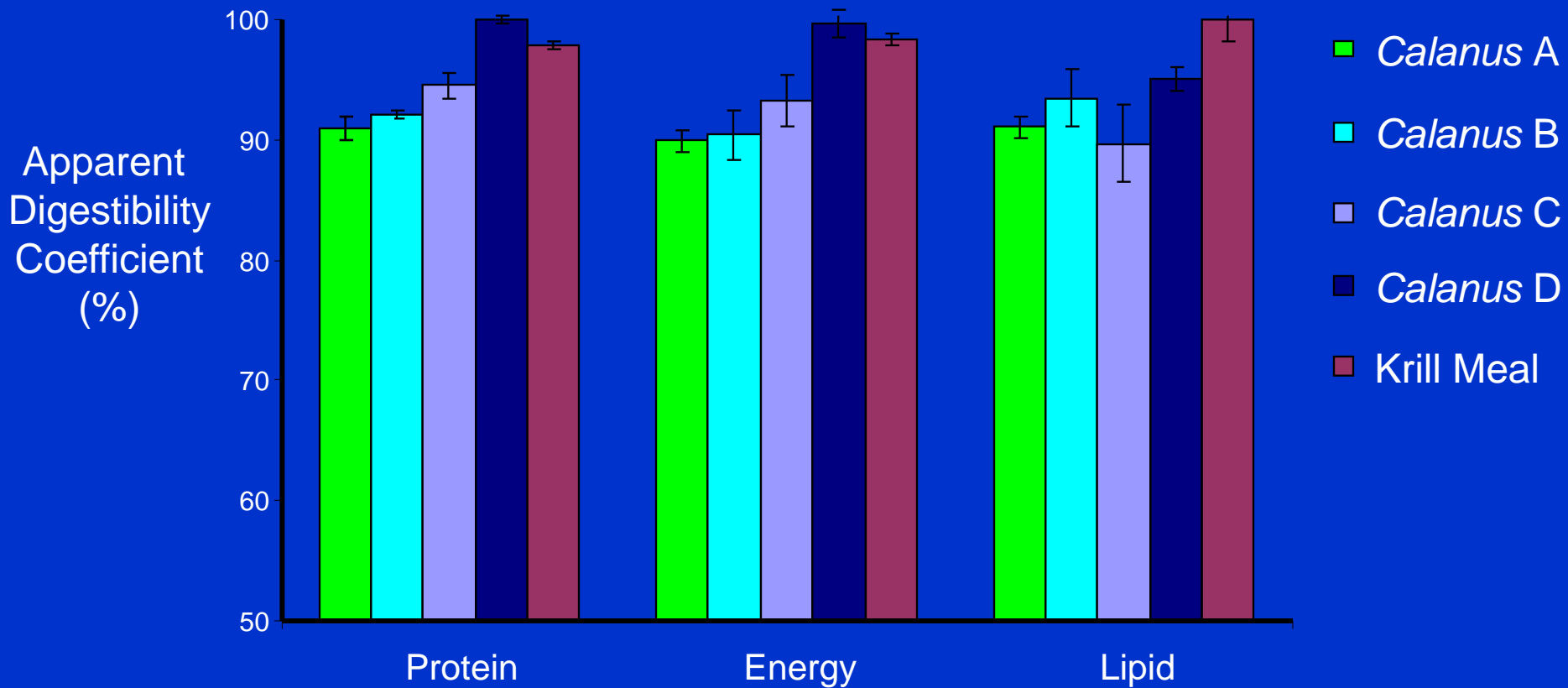


Practical Use

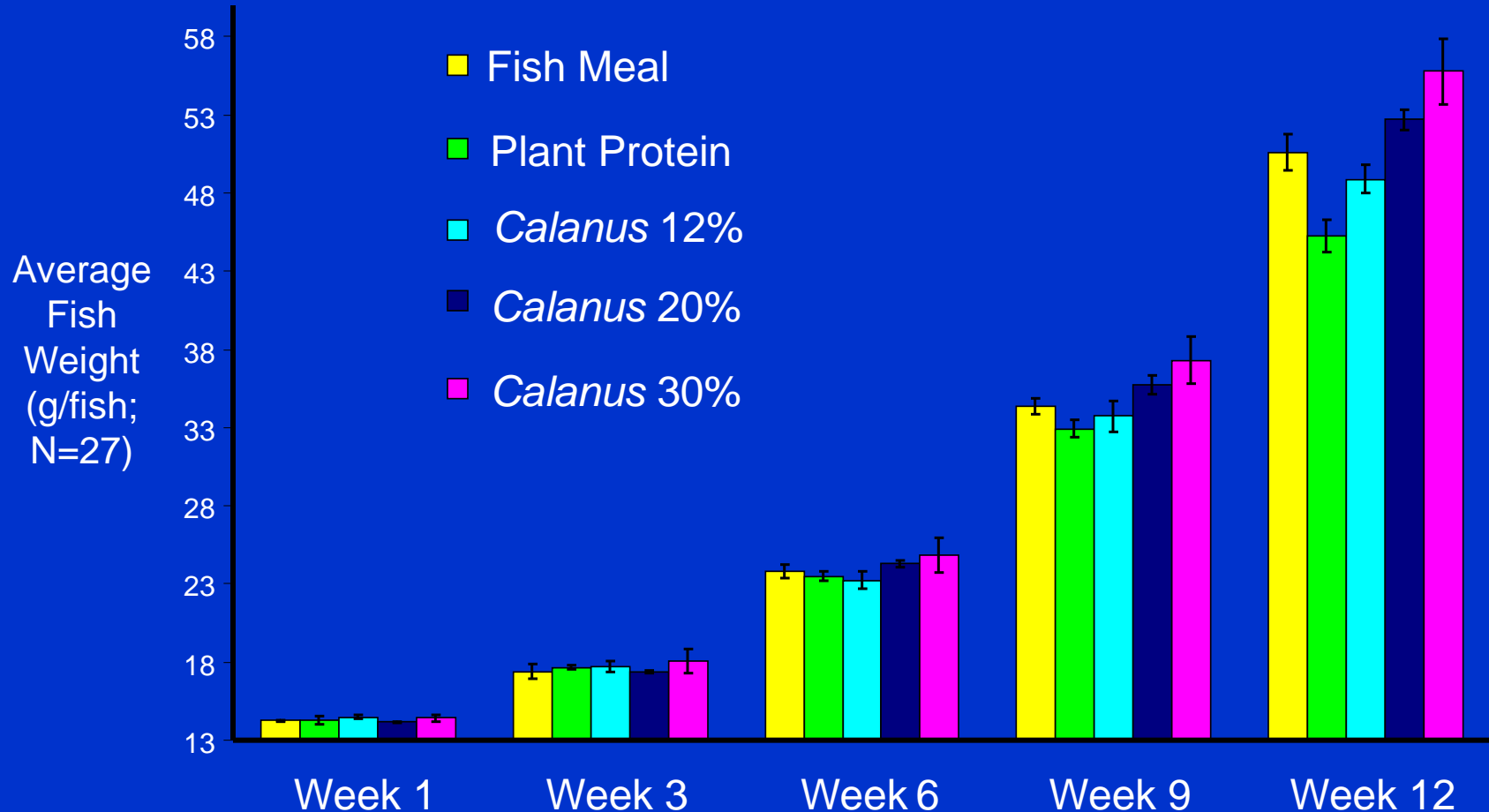
- Need to establish precautionary catch limit
- Need to determine cost-effectiveness \$\$\$
 - Balance between good nutrition and cost
 - Combination with other nutrient sources
- Future as staple feed ingredient?
 - Sustainable? Economical?



Lipid, protein and energy digestibility of *Calanus* and krill by halibut



Growth of halibut fed diets with graded levels of plant protein and *Calanus* protein in replacement of fish meal



Conclusion

- Necessary to reduce use of fish meal and oil in commercial feeds for marine fish
- Plant protein and lipid alone cannot support health and growth of fish
- Marine sources ideal nutrient source
- Studies show high digestibility and growth of halibut fed *Calanus* copepod and krill protein and lipid

Future Direction

- Continue research efforts to replace both fish meal and oil in fish feeds
- Establish balance between zooplankton harvest and marine resource sustainability
- Investigate other marine resources- e.g. algal oil
- Recommend maximum level of fish meal and oil to be used in commercial feeds
- Maintain nutritional value and “image” of fish as healthy food

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