

## **PCCRC Projects Progress Report**

***Project Title: Development of Value-added Market Opportunities for Pollock Co-products***

PIs: Q. Fong, C. Dewitt, and M. Kohan

Pollock milt and roe from Pollock have been collected. The process of isolating nucleic acid is being continued. As for market assessment, market scanning has been completed. Enclosed is a summary report. The PIs will gather in March to determine the next steps as preliminary results of the nucleic acid isolation are being analyzed.

## **Preliminary Market Scanning of Nucleotide Products**

Alina Fairbanks, Student Intern, BA Fisheries, University of Alaska Fairbanks;  
Quentin Fong, Seafood Marketing Specialist, Alaska Sea Grant Marine Advisory Program and Department of Fisheries, University of Alaska Fairbanks; Michael Kohan, Technical Program director, Alaska Seafood Marketing Institute; Christina Dewitt, Director, Seafood Research and Education Center, Oregon State University.

### **Justification**

The seafood industry is crucial to Alaska's coastal economy. The industry, consisting of commercial harvesters, processors, and related industries such as hatcheries and fisheries management to increase/maintain production and/or ensure sustainability employs approximately 60,000 people that accounts for \$2.1 total labor income, and generates US\$6.2 billion in direct output in the state. Alaska as a seafood supplier plays a significant role in the U.S. Alaska consistently supplies more than 55% of the country's landing in volume, exports to more than 100 countries value at US\$3.2 billion, 55% of total export value from U.S. It is also estimated that two-third of the value of seafood products sold domestically originated from Alaska. (McDowell Group, 2015; USDOCa various years; USDOCb, various years). However, harvests in Alaska has reached a level where more harvest would jeopardize the biological sustainability of Alaska's fish stocks and thus the economic sustainability of the state's coastal communities.

Further, the food business, including that of Alaska seafood, is an intensely competitive market defined by slim profit margins, coupled with continually changing consumer preferences and volatility, uncertainty of supply especially from wild-caught seafood, and macroeconomic and global/domestic political environment such as currency exchange rates and trade policy. At the food retail level, the average net profit margin for a grocery business is less than 2%, reflecting the lack of pricing power due to competition, which drives food retailers to consider alternatives, including merger and acquisitions to pursue alternate growth opportunities and optimize capital resource allocation. The recent acquisition of Whole Foods by Amazon is one example of retail consolidation (Gurman and Townsend, 2017; FMI Various Years).

The aforementioned factors affecting food businesses also affect the Alaska seafood industry. Alaska Pollock, the largest fishery in Alaska in volume (54%) and value (25%), have seen their premium market share eroded due to the certification of Russian Pollock by the Marine Stewardship Council, the continue decline of price received from Pollock roe due to the changes of tastes and preferences of the primary market in Japan, and the strong US dollar which renders the exports of US produced Pollock more expensive in the world market. Moreover, the traditional products such as surimi, roe, and fillet utilizes approximately 50% of the fish, the rest is discarded as waste or used as low value co-products such as fish meal (USDOCa; USDOCb).

The overall objective of this work is to determine whether processors in Alaska would be able to increase the economic return from a co-product such as Pollock milt and an existing product facing declining revenue such as Pollock roe by examining the feasibility of extracting and processing nucleotides from the said products and by examining the potential of fish based nucleotides in the marketplace. Nucleotide is chosen due to the purported nutritional benefits of

nucleotide supplements. They have been described as being semi-essential under conditions of ill-health, poor diet or stress. Reports include the ability of dietary nucleotides to modulate immune responses in humans (Gil 2002) and grouper (Lin et al. 2009); response to stress in humans (Palermo et al., 2013), catfish (Welker et al., 2011), pigs (Salobir et al., 2011) and essentially extend endurance in athletes (McNaughton et al., 2006, McNaughton et al., 2007, Ostojic et al., 2012; Palermo et al., 2013; Sterczala et al., 2015). They also include reports of some improvement to people experiencing Irritable Bowel Syndrome (Dancey et al., 2006), improvements in diarrhoeal disease in infants (Brusner et al., 1994) and early weaned pigs (Martinez-Puig et al., 2007).

While the cited work has demonstrated the benefits of nucleotides, no public document has describe the market of nucleotide except for research reports compiled by consulting agencies that costs thousands of dollars. This work intend to conduct market scanning through the internet to answer questions such as: How big is the market? What are the raw ingredients used to produce nucleotides? Who are the producers? Who are the wholesale and retail buyers? What attributes are buyers looking for?

## **Methodological Approach**

A search of the internet was conducted to gather information on companies that are involved in the nucleotide value-adding chain. The following company attributes are recorded: Company name, country the company is headquartered, position in the value added chain (e.g. vertically integrated, wholesale etc.), source of nucleotide (e.g. yeast), product specification and form, price (if available), product brand name, address and contact, and general notes about the company.

## **Results**

### **A. Overview**

Three hundred and fifty-six companies and websites were evaluated, 46 companies were found to be relevant to this project. Of the 46 companies, 14 (28%) are vertically integrated, 10 (20%) are trading companies, 8 retail, 4 manufacturing, and 2 engage in the wholesale sectors (Table 1). With respect to the country of the companies are located and the type of markets they serve, the majority of the companies are based in the US (21), followed by China (13), United Kingdom (4), and Germany (2). India, New Zealand, Spain, Switzerland, and Philippines, have one company each, and one company did not list their location (Table 2). For the types of markets they serve, results show that 18 of the companies sell to the human dietary supplement market, 6 are for animal feed, 5 to the infant market as baby formula, one both animal feed and dietary supplement, 3 produces nucleotide for research needs, and 13 unspecified. Further, 10 companies serve the export markets, and 3 manufacturers that produce nucleotides as raw material (Table 3).

## **B. Source of Nucleotides**

One of the objectives of this work is to examine if there are any demand for nucleotides extracted from fish. Table 4 lists the raw material used to produce or claim the presence of nucleotide. Out of the 46 companies that produces or sell products with nucleotides, 23 (50%) did not list the raw material which the nucleotides were derived from. Of the companies that reported, 10 listed their nucleotide source as yeast, 6 reported from animal products, 5 of which are bovine based, and 1 from pig spleen. Five other companies did not explicitly list their source but marketed their products as vegan, prompting the researchers to categorize it as plant or yeast based. Two companies who supplies chemicals to the research community has nucleotide products from multiple sources, including that of salmon, beef and yeast. Included in this list are 7 companies that do not specifically include nucleotide as a distinct ingredient but claim that their products have high levels of nucleotide.

## **C. Markets Serves and Product Forms**

The investigators also examined the product forms that nucleotide are traded in the market place. They also investigated the companies involved and the channels they sell through.

### ***Nutritional Supplement Market***

Eighteen companies are engaged in providing the nutrient supplement market with products that contain nucleotides. Of the 18 companies, 6 marketed their products specifically as nucleotide supplements, the rest listed or claimed that it is part of the supplement to promote well-being. Product forms that serve this market come in capsules (11 companies), tablet (5 companies) and liquid (2 companies). With regards to origin of nucleotides, 4 companies listed vegan, 4 from animal, 3 listed yeast, 1 plant-based, and 5 did not list their source of nucleotide.

Outlets for the products include company websites and also online retailers such as ebay, Amazon, and physical stores such as Walmart .

### ***Animal Feed Supplement***

For the animal feed supplement category, 7 companies were located from our web survey. Of the 7 companies, one, Bioiberica Nucleoforce is specifically made up of 100% free nucleotide that is extracted from yeast. The rest are a mix that marketed as animal feed supplement for species specific animals. All products came in powdered form manufactured from yeast (5 companies and two products did not specify the source of nucleotides (2 companies).

Product outlet includes on-line retailers such as Amazon, direct web-sales, and strictly wholesale. For example, the brand Ramard has products in hundreds of retail stores.

### ***Manufacturer***

Three companies were identified as manufacturers of nucleotides. All are based in China. Source of nucleotide for each company are reported to be plant based, yeast, and not specified. All three company's product came as pre-mixed powder.

### ***Baby Formula***

Five companies produce baby formula that includes nucleotides as part of the ingredient. Three companies products consist of powder, 2 have both powder and liquid product form. None of them listed the source for nucleotides. Some of these products are sold in Target and Walmart retail stores.

### ***Research Supplies***

Three companies are providing nucleotides for research purposes. All are multi-national chemical companies. For example, Sigma-Aldrich is a subsidiary of Merck. All the products listed come in powder form and are from different raw ingredients, salmon, yeast, bovine are available.

### ***Trading Companies***

Ten out of 46 companies profiled that engage in the nucleotide business are trading companies. All these companies are based out of China selling their product in powder form, promoting their products as flavor and/or nutritional enhancers.

Source of the nucleotide powder traded are yeast (4 companies), pig spleen (1 company), with 4 companies did not specify their source of nucleotides.

## **D. Discussion**

This preliminary market scanning of the nucleotide consists of internet search of companies engaged in the value adding chain, from manufacturers to retailers. In all 46 companies were identified. The majority of the companies are based in the US (21), with 13 based in China, 6 others are based in European, three others based in India, New Zealand and Philippines. No identifiable patterns of whether companies in the US and Europe specialize their products in a particular value-adding segment - manufacturers, vertically integrated operations, and retail only businesses are all represented in the sample. China on the other hand specializes in manufacturing and export of nucleotide as raw material to be incorporated in upstream value chain manufacturing. The rest of the companies, the one based in New Zealand (Lifestream International Ltd.) is a manufacturer/wholesaler for dietary supplement market, India (A.A. Exotic Biosolutions Ltd.) is a manufacturer of animal feeds, Imuregen in the Philippines engages in manufacturing and retail. This shows that the nucleotide market is multi-level and global.

The researchers also examine the origins of nucleotide from the surveyed companies. Results show that 50% of the companies surveyed do not list the origins of nucleotide, including all 5 companies surveyed that engage in the baby formula market, and 7 out of the 10 companies from China that engages in trade. Specifically, for the nucleotide supplement market, 5 out of 18 companies did not list their source of nucleotides, 2 out of 5 companies that serve the animal feed supplement market, 1 out three nucleotide manufacturers, and 1 out of 3 suppliers to scientific research institutions did not list their source of nucleotide. Further, out of the 46 companies, 7 companies claim their product having high concentration of nucleotides without listing specific nucleotide concentration or as ingredients in their products. These results show that the nucleotide market is multi-segmented, with products targeted for end-users who prefer products with nucleotide source information while others do not. One interesting note is that all 5 baby formula market products do not label their source of nucleotides, implying that end-users of that market do not have a preference where the source of nucleotide comes from, which make sense since milk is the main source of nutrients for infants, whether the source is bovine or yeast based may not make a difference.

With regards to who's who in the nucleotide market, it can be surmised that nucleotides, whether as part of the ingredient in nutritional supplement, feed, or baby formula, can be considered a mainstream product positioned in all market channels. For example, in the nutritional supplement market, Nestle Health Science, a subsidiary of Nestle Group, one of the largest food and beverage companies in the world with annual sales of 89 billion USD in 2016, has positioned Impact Advanced Recovery, a nutritional dietary drink “contains a unique blend of specific nutrients (arginine, omega-3 fatty acids, and dietary nucleotides)” for recovery after major surgery. This product is sold in mainstream market outlets such as Walmart (Figure 1). For the animal feed industry, Bioiberica S.A.U., a privately held biotech company in Spain, who produces 20% of the world's heparin with presence in over 65 countries, manufactures Nucleoforce a concentrate of free nucleotides specifically designed for animal health obtained from dried yeasts extracts. (Figure 2).

Multinational food and beverage, health care, and pharmaceutical companies such as Nestle, Abbott Laboratories, and Perrigo Company PLC. also participate in the baby formula market with nucleotide as part of the ingredient. For example, Gerber (subsidiary of Nestle) has *Stage 1 GERBER GOOD START* formula that contains nucleotides and is sold in Walgreens, Target, Walmart and Amazon (Figure 3). Other products such as *Similac Pro-Advance*, a product manufactured by Abott Laboratories, and *Parent's Choice™ Baby Formula* manufacture by Perrigo Nutritionals LLC. is sold exclusively at Walmart.

In summary, the use of nucleotides is well established in the global marketplace. Without further investigation, whether using fish as a label as marketing tool may not establish as a competitive advantage at this time. However, certain fish species or certain co-products of a fish may have a higher amount of nucleotide than other sources and may be labeled as a good source for nucleotides. This work is the first step.

## References

- Brunser, O., Espinoza, J., Araya, M., Cruchet, S., & Gil, A. 1994. Effect of dietary nucleotide supplementation on diarrhoeal disease in infants. *Acta Paediatrica*, 83(2), 188-191.
- Dancey, C. P., Attree, E. A., & Brown, K. F. 2006. Nucleotide supplementation: a randomised double-blind placebo controlled trial of IntestAidIB in people with Irritable Bowel Syndrome [ISRCTN67764449]. *Nutrition journal*, 5(1), 1. Gil, A. "Modulation of the immune response mediated by dietary nucleotides." *European Journal of Clinical Nutrition* 56 (2002): S1-4.
- Gurman, M. and M. Townsend. 2017. Amazon to Cut Prices at Whole Foods After Acquisition Closes. <https://www.bloomberg.com/news/articles/2017-08-24/amazon-pledges-lower-prices-as-acquisition-of-whole-foods-closes>.
- Food Marketing Institute. Various Years. Grocery Store Chains Net Profit. <https://www.fmi.org/our-research/supermarket-facts/grocery-store-chains-net-profit>
- Lin, YH, Wang, H, & Shiau, SY. 2009. Dietary nucleotide supplementation enhances growth and immune responses of grouper, *Epinephelus malabaricus*. *Aquaculture Nutrition*, 15(2), 117-122.
- Martinez-Puig, D., Manzanilla, E. G., Morales, J., Borda, E., Pérez, J. F., Piñeiro, C., & Chetrit, C. 2007. Dietary nucleotide supplementation reduces occurrence of diarrhoea in early weaned pigs. *Livestock science*, 108(1), 276-279.
- McDowell Group. 2015. The Economic Value of Alaska's Seafood Industry - Ebook prepared for the Alaska Seafood Marketing Institute. [http://ebooks.alaskaseafood.org/ASMI\\_Seafood\\_Impacts\\_Dec2015/#/0/](http://ebooks.alaskaseafood.org/ASMI_Seafood_Impacts_Dec2015/#/0/) 31 pp.
- Mc Naughton, L., D. J. Bentley, and P. Koepfel. 2007. The effects of a nucleotide supplement on salivary IgA and cortisol after moderate endurance exercise. *Journal of sports medicine and physical fitness* 46(1): 84.
- Mc Naughton, Lars, David Bentley, and Peter Koepfel. 2007. The effects of a nucleotide supplement on the immune and metabolic response to short term, high intensity exercise performance in trained male subjects. *Journal of sports medicine and physical fitness* 47(1): 112.
- Ostojic, Sergej M., and Milos Obrenovic. 2012. Sublingual nucleotides and immune response to exercise. *J. Int. Soc. Sports Nutr* 9 (2012): 31.
- Palermo, Francesco Alessandro, et al. 2013. Effects of dietary nucleotides on acute stress response and cannabinoid receptor 1 mRNAs in sole, *Solea solea*. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* 164.3 (2013): 477-482

- Sterczala, et al. 2015. The Physiological Effects of Nucleotide Supplementation on Resistance Exercise Stress in Men and Women. *Journal of Strength and Conditioning Research* 29(3): 612-618.
- USDOCa. Various Years. National Marine Fisheries Service Commercial Fisheries Statistics – Commercial Landings. <http://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/index>
- USDOCb. Various Years. National Marine Fisheries Service Commercial Fisheries Statistics – Foreign Trade. <http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/index>
- Welker, T. L., Lim, C., Yildirim-Aksoy, M., & Klesius, P. H. 2011. Effects of dietary supplementation of a purified nucleotide mixture on immune function and disease and stress resistance in channel catfish, *Ictalurus punctatus*. *Aquaculture Research*, 42(12), 1878-1889.
- West, Daniel WD, and Stuart M. Phillips. 2012. Associations of exercise-induced hormone profiles and gains in strength and hypertrophy in a large cohort after weight training. *European journal of applied physiology* 112(7): 2693-2702.



<b>Table 1. Chain Position</b>	<b>Number</b>
Manufacturer	4
Wholesale	2
Retail	8
Vertically Integrated	14
Trading	10
Nucleotide Claim	8
Total	46

<b>Table 2. Country of Origin</b>	<b>No. of Companies</b>
US	21
China	13
UK	4
Germany	2
India	1
Spain	1
Switzerland	1
Philippines	1
New Zealand	1
Unknown	1
Total	46

<b>Table 3. Markets Served</b>	<b>No. of Companies</b>
Dietary Supplement	18
Baby Formula	5
Animal Feed	6
Research	3
Animal Feed/Dietary Supplement	1
Export Market	10
Undefined (Manufacturers)	3
Total	46

**Table 4: Source of Nucleotides**

<b>Source</b>	<b>Number of Companies</b>
Yeast	10
Plant	1
Plant or Yeast*	5
Animal*	5
Multiple	2
Unknown	23
Total	46

\*Note:

Plant or Yeast - products claimed to be vegan

Animal - 5 bovine , 1 from pig spleen

Multiple - salmon and other sources

**Figure 1. Nutritional Supplement Product Example - Impact Advanced Recovery**



**Figure 2. Animal Feed Product Example – Nucleoforce**



**Figure 3. Baby Formula Product Example - Stage 1 GERBER GOOD START**



## Appendix: Surveyed Companies

Market Served/Company Name	Country	Source	Product Name
<b><u>Dietary Supplement</u></b>			
InVite Health	U.S	Yeast	Nucleotide Complex
Bluebonnet	U.S	Torula Yeast	Nucleotide Complex Vegetables Capsules
Quantum Nutrition Labs	U.S	Plant or Fungus	Nucleotide Complex Quantum
Doctor's Natural Health Solutions	U.S	Yeast	Intestinal Balance Supplement AID
Nucleotide Nutrition	UK	Plant or Fungus	IntestAidIB, Nucell...
Swanson Ultra	U.S	Yeast	Mixed Nucleotides with Imunli
Jarrow Formulas	U.S	Plant or Fungus	Uridine
Nestle Health Science	Switzerland	Unknown	Impact Advanced Recovery
Lipolife	U.K	Plant or Fungus	Liposomal Nucleotide Complex
Imurgen	Philippines	Bovine	Imuregen
Rx Vitamins Physician Formulated	U.S	Unknown	Advanced Immune Support
Fractal Health LLC	U.S	Unknown	$\beta$ - Nicotinamide Mononucleotide
Premier Research Labs	U.S	Fungus or Plant	Nucleo Immune
Lifestream International Ltd.	N.Z.	Plant	Lifestream Chlorella
Standard Process	U.S	Bovine	Parotid PMG
Douglas Laboratories®	U.S	Bovine	Colostrum
Nutricology	U.S	Bovine	Laktoferrin with Colostrum
Nature's Plus	U.S	Unknown	Ribose Rx-Energy® Tablets
<b><u>Animal Feed</u></b>			
Provetria	U.S	Yeast	NucleOtics
Blue Chip Feed Limited	U.K	Unknown	Stallion SPM-20
Novity Pet	U.S	Unknown	Organic Hip and Joint Supplement
Good Dog Charlie	Unknown	Unknown	Rescue One
Ramard	U.S	Yeast	Ramard Total GI Health, Total Gut Health
A.A. Exotic Biosolutions Pvt. Ltd	India	Yeast	Nucleo Pro-C, Nucleo-R
Bioiberica	Spain	Yeast	Nucleoforce

**Manufacturers**

Xi'an Plant Bio-Engineering Co., Ltd.	China	Plant	Nucleotide Powder
Star Lake Bioscience Co	China	Unknown	Disodium 5'-Ribonucleotide(I+G)
Nanjing Biotgether Co., ltd	China	Yeast	Nucleotide Premix

**Baby Formula**

SMA Nutrition	U.K	Unknown	PRO Toddler Milk with NUTRI-STEPS®...
Similac (Brand of Abbott)	U.S	Unknown	Pro-Advance
Gerber (Nestle owned)	U.S	Unknown	Stage 1 Gerber Good Start
Mead Johnson	U.S	Unknown	Enfamil Formulas: Newborn
Perrigo Nutritionals LLC	U.S	Unknown	Parent's Choice

**Supplier for Reseach****Institutions**

Jena Bioscience Research	Germany	Unknown	None
Sigma-Aldrich Research	Germany	Variety: Bovine, Salmon	N/A
BD Biosciences	U.S	Bovine based/yeast	BD BBL Beef Extract

**Trade**

Xi'an Hao-Xuan Bio-Tech Co, Ltd	China	Yeast	Nucleotide 99% powder CAS 58-96-8
Shanghai Yaokuo Herbal Biological Technology Co., Ltd.	China	Unknown	beta-Nicotinamide-adenine Dinucleotide
Shanghai Sunway Pharmaceutical Technology Co., Ltd.	China	Unknown	beta-Diphosphopyridine nucleotide
CBH Qingdao Co., Ltd.	China	Yeast	Bionutrend Nucleotide Feed Grade
Bontac Bio-Engineering Co., Ltd.	China	Unknown	β-Nicotinamide adenine dinucleotide
Zhengzhou Sigma Chemical Co., Ltd.	China	Unknown	Uridine
Hangzhous Huadi Co. Ltd.	China	Pig Spleen	Spleen Nucleotide and Peptides
Shanghai Yaokuo Herbal Biological Technology Co. Ltd.	China	Unknown	Nicotinamide adenine dinucleotide

Shaanxi Orient Industrial Co., Ltd.	China	Unknown	Nucleotide (Feed Grade)
ChemFine International Co., Ltd.	China	Unknown	Food flavor enhancer Nucleotide