Product Development for Cownose Ray

Final Report

Submitted to:

Virginia Marine Resources Commission (VMRC)
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Submitted by:

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VIMS Marine Resource Report No. 2012-5
VSG-12-08

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VMRC Project Final Report

I. Product Development for Cownose Ray
Principal Investigator, Robert A. Fisher, CF 06-04, July 1, 2006 to September 30, 2011

II. *Executive Summary*

Various products from cownose ray were investigated within this project, from various human consumption products to bait for other fisheries. Collaborative efforts to demonstrate commodity use for the ray was performed between academia and various industries, including: fishing, seafood, pharmaceutical, pet food, and clothing. Products rendered for human consumption show tremendous potential, however, strong and effective consumer education together with dedicated commercial harvesting of ray is needed for products penetration into the various markets. Though cownose ray flesh maintains health-wise benefits of a low fat protein source, consumer acceptance of fish which deviates from the engrained idea that fish should be white and flaky, is paramount for ray market expansion. Likewise, without a sustainable supply of ray from a targeted or by-catch fishery, other viable ray product forms, as liver oil, cartilage, skin (leather), and bait markets will remain skeptical and hesitant to invest in products without consistent production. This project identified plausible markets for the cownose ray resource in the Chesapeake Bay, while also complimenting other funded projects (Fishery Resource Grants and NOAA) researching ray utilization.

III. *Purpose*

A. Overarching goal(s) of the project.
Collaborating with fishermen and seafood processors, cownose rays from various locations in the Chesapeake Bay were harvested and process for both, biological information and for various marketable products. Engaging all stakeholders in this project, from fisher through processor/distributor to consumer, was deemed highly important to establish economic viability of marketing cownose ray. Biological information derived from this effort was incorporated in a large NOAA funded project assessing the cownose ray population in the bay to support sustainable harvesting of ray if a commercial harvest was initiated.

B. Hypotheses (if applicable) and objectives of the project.

Fresh cownose rays were processed in various manners to obtain potential marketable products.

IV. *Approach*

A. Detailed description of the work that was performed.
See Attachment.

B. Project management: List individuals and/or organizations actually performing the work and how it was done.

This project was managed and performed by Robert Fisher, Virginia Sea Grant Marine Advisory Services, Virginia Institute of Marine Science, College of William and Mary. Work was performed by Fisher with collaboration with Virginia Marine Products Board, Virginia Marine Resources Commission, various local watermen, shellfish aquaculture companies, seafood processors/distributors, exporters, Virginia Tech colleagues, VIMS

colleagues, individual chefs, culinary Institutes, and various external industries [pharmaceutical, leather tanning, fishing (bait usage), and food and supplement nutritional testing labs.

V. *Findings* - See Attachment.

A. Actual accomplishments and findings.

1) This project provided additional ray population information and was incorporated into a NOAA report which is positioned to be used by management if a commercial fishery is established. (NA07NMF4570324; Fisher, R.A. 2010. Life history, trophic ecology and prey handling by cownose ray, Rhinoptera bonasus, from Chesapeake Bay. VIMS Marine Resource Report No. 2010-20, VSG-10-25).

This project also provide industry with baseline product information, as nutritional and proximate values, processing controls, fresh product shelf life, chef trials and consumer education, as well as domestic and export market penetration avenues for various product forms.

B. Description of need, if any, for additional work.

Marketing a seafood product which does not adhere to traditional consumer perceptions of seafood needs a vigorous education component for successful penetration. Education on cownose ray was greatly needed, and subsequently provided by this project through all stages of product utilization, starting with the fishermen and extending through the processor, distributor, retailer, and end user (restaurants and consumers). Extensive effort was given to familiarize cownose ray in the market chain throughout this project period. However, continuation of the education component is needed, as well as consistently available ray product(s) for further expansion of cownose ray markets to be realized.

VII. *Applications*

Outputs and management outcomes achieved. Outputs are defined as products (e.g. publications, models) or activities that lead to outcomes (changes in user knowledge or action).

Management and/or regulatory related outcomes from this project included:

2) Final report to NOAA (NA07NMF4570324); Fisher, R.A. 2010. Life history, trophic ecology and prey handling by cownose ray, Rhinoptera bonasus, from Chesapeake Bay. VIMS Marine Resource Report No. 2010-20, VSG-10-25.

3) HACCP plan for processed ray products for human consumption.

A. Outputs

i. New fundamental or applied knowledge
Final report to NOAA (NA07NMF4570324); Fisher, R.A. 2010. Life history, trophic ecology and prey handling by cownose ray, Rhinoptera bonasus, from Chesapeake Bay. VIMS Marine Resource Report No. 2010-20, VSG-10-25.

ii. Scientific publications
iii. Patents

iv. New methods and technology
See HACCP plan

v. New or advanced tools (e.g. models, biomarkers)
vi. Workshops
vii. Presentations
viii. Outreach activities/products (e.g. website, newsletter articles)

Cownose ray products were featured at two Marine Science Days held at VIMS (2007, 2008). Whole cownose ray were presented during an education lecture on the species and how ray is harvested and processed, followed by preparation of several different ray dishes by invited chef for attendees to try.

Cownose ray was featured at the Chef Symposium held at VIMS in 2009. This education event brings chefs and culinary students from around the state together for lectures and cooking demonstrations in which credit hours are earned (110 in attendance). A lecture on cownose ray was given, which included specie specific biological information, harvesting and processing, and nutritional/proximal profiles of ray flesh, followed by cooking demonstrations by several chefs using different ray recipes.

Media Day was held (2008) at a large oyster company (collaborator with this work) with local and regional media coverage detailing the situation of cownose ray predation on oysters. An invited chef, culinary instructor at regional college, demonstrated various market cuts of cownose ray and cooked 2 different dishes for media personnel testing. Newspaper and magazine coverage resulted from this event providing information to the public on cownose ray-oyster interaction and the availability of ray products (with recipes) for consuming. Working with this chef, 10 recipes for cownose ray was formulated and publicized.

Article published in the *Virginia Marine Resource Bulletin* (2007) highlighted contributions made by this project. "Everybody Loves Ray," *Virginia Marine Resource Bulletin*, Vol. 39, No. 2, 2007.
(http://vaseagrant.vims.edu/wp-content/uploads/2011/04/vmrb_summer07.pdf)

Cownose ray recipes generated for distribution;
http://web.vims.edu/rayrecipes/?svr=www

VIII. *Evaluation*

Describe the extent to which the project goals and objectives were attained. Provide explanation for modification of goals and objectives.

This project allowed for initial marketing attempts for various cownose ray products. Fundamental information was generated providing the basis from which further product developing and marketing efforts may expand. Attempts to establish a commodity value for cownose ray was curtailed largely due to wholesaler/distributor reluctance to prioritize ray as a new product, further suppressing consumer experience with, and education on this species as a food source. A stronger and more concerted buy-in from all aspects of seafood product marketing (harvester, processor, distributor, wholesaler, retailer, and academia/state marketing agencies/culinary groups), will need to be established and maintained for successful marketing of cownose ray to US consumers.

Attachment to VMRC Final Report:

Product Development for Cownose Ray - 7/1/06–9/30/11

Approach and Findings

The Virginia Sea Grant Marine Advisory Program (VA SGMAP) has responded to industry concerns with cownose ray predation on shellfish in the Chesapeake Bay and their impact on submerged aquatic vegetation (SAV) starting in the late 1980s and continuing to present studies focused on developing ray product markets and the potential for a ray fishery. Through demonstration projects VA SGMAP at VIMS has provided industry with valuable ray harvesting, processing, and marketing information.

Studies performed in the mid-1970s, and subsequently reported on in the early 1980s, reported on the ray social behavior, diet and some means to keep the rays off shellfish beds. These studies may be outdated. Since the time of these studies, some things have changed, including the reported increased number of rays and the shift in the main prey species of rays (was the soft clam in the 1980s, but those clams are no longer abundant). The continual loss of SAV remains a concern as well, with ray feeding mechanics adding to this problem.

The Virginia Fishery Resource Grant Program (FRG) funded project entitled, "Value of Cownose Ray: Population Size, Harvesting, Processing and Market Acceptance," in cooperation with VA SGMAP at VIMS, has expanded on previous efforts to establish markets for the cownose ray, mainly within the bait market. This project has also help create a collaborative atmosphere among various Virginia fisheries and between those fisheries and research and regulatory agencies. In addition, it has elicited information requests from other states (Florida, North Carolina, Maryland, and New Jersey) regarding similar problems with cownose rays. The cownose ray has become a regional issue, especially in areas where shellfish restoration efforts are being conducted FRGP are ear-marked for the purchase of rays, cold storage, and local travel/transportation to collect biological information. These rays are needed to exploit various domestic and international ray meat markets as well as to provide needed biological and social behavioral information on the cownose ray population in the Bay. This life history information will be needed for fishery management implications and was largely incorporated with data generated for the NOAA funded project.

To fully exploit the potential of these efforts, additional funds were petitioned for and granted from VMRC. Funding from Virginia Sea Grant was petitioned for and granted to convene a regional workshop in Yorktown, Virginia to provide information relative to the cownose ray issue to research groups, regulatory agencies, and the fishing industry. Funds for

this VMRC project are to support cownose ray biological information data collection and the processing of cownose ray for products by VIMS scientists, and marketing efforts by the Virginia Marine Products Board.

The Virginia Marine Products Board has worked in 2005-2006 with the seafood industry and the Virginia Institute of Marine Science to explore the market potential for the cownose ray. South Korea was identified as a potential market for ray after learning that ray wings are a common food service product. Meetings were held with VMPB staff and three large skate and ray importers to develop market research. Buyers were interested in ray from Virginia if the quality and packaging was the same as current suppliers and the price is competitive.

Seafood importers, buyers and customers sampled cooked ray at the Busan International Seafood Show in Busan, S. Korea. Hotel customers—both Korean and American--tasted grilled ray during a Great American Seafood Festival and the ray from Virginia was given rave reviews.

Whole ray, wings and loins have been displayed at the International Boston Seafood Show and European Seafood Exposition. Buyers expressed some interest for the international markets. Cownose ray was prepared at the John Folse Culinary Institute for international chefs and the Northeast Regional Conference of the American Culinary Foundation with chefs expressing interest in testing the product in their markets. Chef John Maxwell, CEC, AAC and culinary instructor at J. Sargeant Reynolds Community College had culinary students work with frozen ray. These early experiments with chefs, culinary students and consumers who sampled ray lead us to believe that there is a domestic food service market for fresh and frozen cownose ray that needs exploring.

Research into ray leather markets provided information of a current market for sting ray leather in Asia. The species used in Asia was not similar to cownose ray skin, but research into domestic processing of cownose ray skin was attempted.

Cownose rays from various locations in the Chesapeake Bay were collected during their residency period (summer) and processed for both, biological information and for various human consumption markets. Working with six different commercial fishermen, rays were harvested by haul seines and pound nets from 6 different sites along the western shore of the Chesapeake Bay. Harvesting sites included Lynnhaven, Poquoson flats, York River, Mobjack Bay, Reedville, and Potomac River. Biological information included stomach content analysis, vertebra sampling for aging determinations, weight and disc length measurements, sexing, and ovary development stages. The rays were processed in various manners to obtain desired marketable products. For marketing efforts for human consumption, cownose ray flank-style fillets (skin-on and skin- off), steak cuts, wing tips, whole wings, and loin cuts were performed

by identified commercial processors, with the resulting products either distributed fresh or commercially frozen to targeted markets or used for culinary product development demonstrations. Expansion on previous bait market efforts was also performed focused on the utilization of the cownose ray processing waste material.

Through the Marine Products Board, test marketing cownose ray in domestic and international markets was performed to determine the acceptance of cownose ray in the marketplace. Samples were distributed to chefs in major markets throughout the region to determine the product types, price, distribution and promotion as well as customer preferences. Chef's feedback was used to determine true demand for the product as well as obtaining product handling, preparation and presentation ideas. Since the name cownose ray is a barrier, a more creative theme line needed to be developed. The market name "Chesapeake Ray" was used during a marketing study in 1991 (Fisher and Lacey, Product Development for the Cownose Ray, Proc. Sixteenth Annual Tropical and Subtropical Fisheries Technological Conference of the Americas, NCSU, NCSGCP, SGR-110) to replace "cownose ray", and adopted for this marketing effort. Fact sheets and wait staff training materials were also developed and produced.

Ray Meat Shelf Life

The shelf-life study on fresh ray wing meat was performed at the Virginia Tech lab in Hampton. Rays were processed 1 day after being landed at Amory's Seafood Co.. Rays were held in refrigeration on ice during this holding period, which would mimic typical processing logistics for this species. Wing fillets greater than .5 inches in thickness were used for this evaluation. Ray meat was processed into 75 ~100 gram samples, placed in pint-size plastic bags with air space removed, then placed in controlled refrigeration. Two holding temperatures were evaluated in this study, 40^0 and 45^0F, with samples stored for 14 days. Results indicated that fresh ray meat has a shelf-life of 6 days at 45^0F and 11 days at 40^0F (Figure below). The organoleptic spoilage indicators produced by the ray meat were ammonia and slight fecal odors, and flesh browning (oxidation). APC counts (cfu/g) for 45^0 held meat averaged 4M at shelf-life termination (day 9), and 500,000 for 40^0 at 12 days.

Sample		Sensory Evaluation	APC@35°C cfu/g	Total Coliform cfu/g	E. coli cfu/g		Sensory Evaluation	APC@35°C cfu/g	Total Coliform cfu/g	E. coli cfu/g
Initial Quality:	a	fresh, no off odors	4,100	< 2	< 2					
	b	good red color	3,600	< 2	< 2					
2 Days storage:	40 a	fresh, no off odors	4,600	4	< 2	45 a	fresh, no off odors	7,400	4	4
	40 b	good red color	4,800	4	< 2	45 b	good red color	4,200	2	2
	40 c	No Ammonia	2,300	4	< 2	45 c	No Ammonia	3,300	8	< 2
5 Days storage	40 a	fresh, no off odors	1,900	4	< 2	45 a	fresh, no off odors	17,000	380	< 2
	40 b	good red color	1,300	8	< 2	45 b	good red color	46,000	48	< 2
	40 c	No Ammonia	3,700	14	6	45 c	No Ammonia	10,000	160	< 2
7 Days storage:	40 a	fresh, no off odors	4,600	4	< 2	45 a	slight sour	500,000	> 5,000	> 5,000
	40 b	good red color	2,100	24	< 2	45 b	OK, no Ammonia	580,000	> 5,000	> 5,000
	40 c	No Ammonia	8,300	44	< 2	45 c	OK, no Ammonia	140,000	260	< 10
9 Days storage:	40 a	no off odors	12,000	28	< 2	45 a	slightly sour	9,400,000	45,000	1,000
	40 b	color good	19,000	8	< 2	45 b	brownish meat	2,000,000	> 50,000	< 10
	40 c	No Ammonia	27,000	44	< 2	45 c	slightly mushy	1,400,000	4,000	< 10
12 Days storage:	40 a	sl. fecal odor, brown	500,000	910	750	45 a	sour, mushy			
	40 b	OK, no Ammonia	900,000	80	< 10	45 b	brown meat			
	40 c	OK odor, brown	120,000	280	140	45 c	all discarded as spoiled			

Ray nutritional analysis and processing controls for ray products (HACCP)

Cownose ray flesh samples were taken from 6 adult rays (3 females and 3 males) in May and again in early September for nutritional profile analysis. These samples were frozen and shipped to a FDA certified laboratory for nutritional and mercury content determinations and the results are below. This nutritional information was used for marketing efforts including product labeling and dietary claims for wholesalers, retailers, and consumer education efforts.

Cownose ray flesh maintained low fat content during the summer period when subjected to potential commercial harvest (0.55g in May; 0.64g in September) verifying a low fat protein source. Mercury content values served to fulfill HACCP Plan requirements for the seafood processors in addressing potential specie Hazards, with results showing accumulating mercury in ray flesh with size (age), but well below the action level of 1ppm.

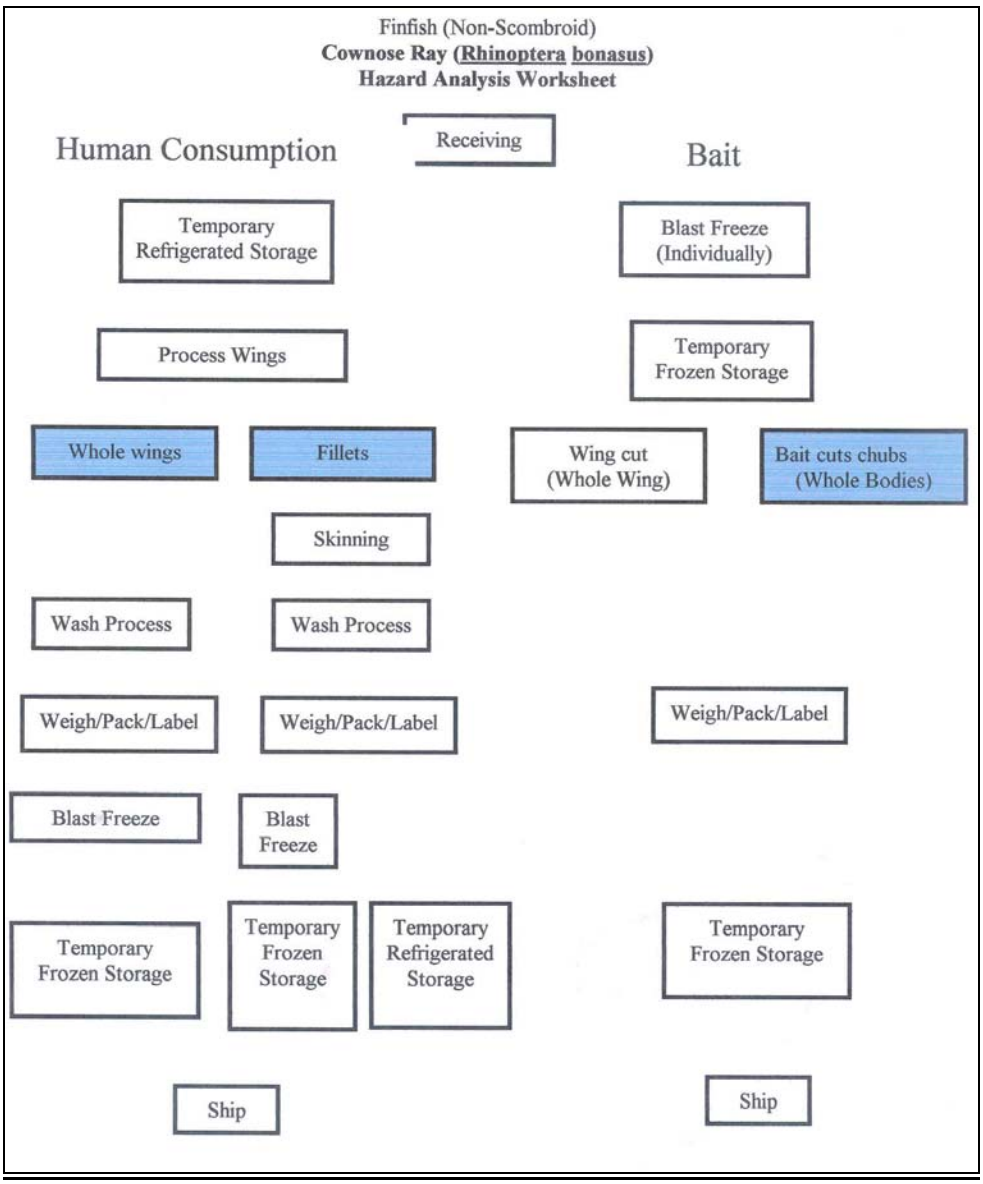
1May 2007 Sample

Nutrient	Per Svg	Per 100g	Nutrient	Per Svg	Per 100g
Fat (g)	0.5500	0.5500	18:2 - Linoleic (g)	0.0721	0.0721
Vitamin A - Carotenoid RE (	--	--	18:1 - Oleic (g)	0.1084	0.1084
Vitamin A - RE (RE)	--	--	16:1 - Palmitol (g)	0.1496	0.1496
Vitamin A - IU (IU)	0	0	14:1 - Myristol (g)	0.0022	0.0022
Vitamin C (mg)	0	0	Trans Fatty Acid (g)	0	0
Total Sugars (g)	0.0250	0.0250	Cholesterol (mg)	56.3000	56.3000
Fructose (g)	--	--	Potassium (mg)	--	--
Glucose (g)	0.0250	0.0250	Caffeine (mg)	--	--
Lactose (g)	--	--	Iodine (mcg)	--	--
Maltose (g)	--	--	Magnesium (mg)	--	--
Sucrose (g)	--	--	Phosphorus (mg)	--	--
Carbohydrates (g)	0	0	Zinc (mg)	--	--
Calories (kcal)	107.250	107.250	Copper (mg)	--	--
Protein (g)	25.6000	25.6000	Manganese (mg)	--	--
Calcium (mg)	6.6500	6.6500	Vitamin B1 - Thiamin (m	--	--
Sodium (mg)	87.5000	87.5000	Vitamin B2 - Riboflavin (	--	--
Iron (mg)	1.7700	1.7700	Vitamin B3 - Niacin (mg)	--	--
Dietary Fiber (g)	0	0	Vitamin B6 (mg)	--	--
Calories from Fat (kcal)	4.9500	4.9500	Biotin (mcg)	--	--
Water (g)	72.5300	72.5300	Vitamin D - IU (IU)	--	--
Ash (g)	1.3900	1.3900	Vitamin E - IU (IU)	--	--
Saturated Fat (g)	0.0666	0.0666	Pantothenic Acid (mg)	--	--
24:0 - Tetracos (g)	0	0	Folic Acid (mcg)	--	--
22:0 - Behenate (g)	0	0	Alanine (g)	--	--
20:0 - Arachidic (g)	0.0534	0.0534	Isoleucine (g)	--	--
18:0 - Stearic (g)	0.0116	0.0116	Methionine (g)	--	--
16:0 - Palmitic (g)	0.0017	0.0017	Serine (g)	--	--
14:0 - Myristic (g)	0	0	Leucine (g)	--	--
12:0 - Lauric (g)	0	0	Tryptophan (g)	--	--
10:0 - Capric (g)	0	0	Valine (g)	--	--
8:0 - Caprylic (g)	0	0	Cystine (g)	--	--
6:0 - Caprioc (g)	0	0	Glycine (g)	--	--
Poly Fat (g)	0.2244	0.2244	Histidine (g)	--	--
Mono Fat (g)	0.2585	0.2585	Tyrosine (g)	--	--
24:1 - Nervonic (g)	0	0	Arginine (g)	--	--
22:6 - DHA (g)	0.1309	0.1309	Lysine (g)	--	--
22:1 - Erucic (g)	0	0	Phenylalanine (g)	--	--
20:5 - EPA (g)	0.0127	0.0127	Proline (g)	--	--
20:4 - Arachidon (g)	0	0	Threonine (g)	--	--
20:3 - Eicosatrienoic (g)	0.0044	0.0044	Vitamin B12 (mcg)	--	--
20:1 - Eicosen (g)	0.0017	0.0017	Vitamin K (mcg)	--	--
18:3 - Linolenic (g)	0.0028	0.0028			

September 2007 sample

Nutrient	Per Svg	Per 100g	Nutrient	Per Svg	Per 100g
Fat (g)	0.6400	0.6400	18:2 - Linoleic (g)	0.0813	0.0813
Vitamin A - Carotenoid RE (	--	--	18:1 - Oleic (g)	0.1158	0.1158
Vitamin A - RE (RE)	--	--	16:1 - Palmitol (g)	0.2195	0.2195
Vitamin A - IU (IU)	0	0	14:1 - Myristol (g)	0.0032	0.0032
Vitamin C (mg)	0	0	Trans Fatty Acid (g)	0	0
Total Sugars (g)	0.0590	0.0590	Cholesterol (mg)	69.8000	69.8000
Fructose (g)	0.0130	0.0130	Potassium (mg)	--	--
Glucose (g)	0.0270	0.0270	Caffeine (mg)	--	--
Lactose (g)	0	0	Iodine (mcg)	--	--
Maltose (g)	0.0190	0.0190	Magnesium (mg)	--	--
Sucrose (g)	0	0	Phosphorus (mg)	--	--
Carbohydrates (g)	0.1700	0.1700	Zinc (mg)	--	--
Calories (kcal)	107.560	107.560	Copper (mg)	--	--
Protein (g)	25.2800	25.2800	Manganese (mg)	--	--
Calcium (mg)	6.1700	6.1700	Vitamin B1 - Thiamin (m	--	--
Sodium (mg)	92.4000	92.4000	Vitamin B2 - Riboflavin (	--	--
Iron (mg)	1.7500	1.7500	Vitamin B3 - Niacin (mg)	--	--
Dietary Fiber (g)	0	0	Vitamin B6 (mg)	--	--
Calories from Fat (kcal)	5.7600	5.7600	Biotin (mcg)	--	--
Water (g)	72.6600	72.6600	Vitamin D - IU (IU)	--	--
Ash (g)	1.2500	1.2500	Vitamin E - IU (IU)	--	--
Saturated Fat (g)	0.0909	0.0909	Pantothenic Acid (mg)	--	--
24:0 - Tetracos (g)	0	0	Folic Acid (mcg)	--	--
22:0 - Behenate (g)	0	0	Alanine (g)	--	--
20:0 - Arachidic (g)	0.0518	0.0518	Isoleucine (g)	--	--
18:0 - Stearic (g)	0.0083	0.0083	Methionine (g)	--	--
16:0 - Palmitic (g)	0.0237	0.0237	Serine (g)	--	--
14:0 - Myristic (g)	0	0	Leucine (g)	--	--
12:0 - Lauric (g)	0.0019	0.0019	Tryptophan (g)	--	--
10:0 - Capric (g)	0.0051	0.0051	Valine (g)	--	--
8:0 - Caprylic (g)	0	0	Cystine (g)	--	--
6:0 - Caprioc (g)	0	0	Glycine (g)	--	--
Poly Fat (g)	0.2106	0.2106	Histidine (g)	--	--
Mono Fat (g)	0.3386	0.3386	Tyrosine (g)	--	--
24:1 - Nervonic (g)	0	0	Arginine (g)	--	--
22:6 - DHA (g)	0.1152	0.1152	Lysine (g)	--	--
22:1 - Erucic (g)	0	0	Phenylalanine (g)	--	--
20:5 - EPA (g)	0.0134	0.0134	Proline (g)	--	--
20:4 - Arachidon (g)	0	0	Threonine (g)	--	--
20:3 - Eicosatrienoic (g)	0	0	Vitamin B12 (mcg)	--	--
20:1 - Eicosen (g)	0	0	Vitamin K (mcg)	--	--
18:3 - Linolenic (g)	0	0			

2Ray processing HACCP Plan Flow Chart



Cownose Ray potential Food Hazard: Mercury

Through EPA, FDA certified laboratories; levels of Mercury in the various size rays are well below action levels and are as follows:

Hazard: Mercury

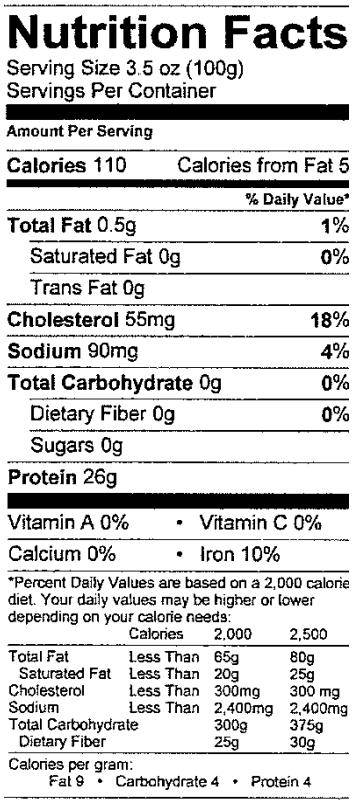
Large Rays; 0.272 ppm (N=3)

Medium Rays; 0.151ppm (N=3)

Small Rays; <0.043 ppm (N=3)

Pups (new born); <0.039 ppm (N=3) *Action level = 1ppm

Nutritional label required by FDA



Nutrition Facts

Serving Size 3.5 oz (100g)
Servings Per Container

Amount Per Serving

Calories 110	Calories from Fat 5
	% Daily Value*
Total Fat 0.5g	**1%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 55mg	**18%**
Sodium 90mg	**4%**
Total Carbohydrate 0g	**0%**
Dietary Fiber 0g	**0%**
Sugars 0g	
Protein 26g	

Vitamin A 0% • Vitamin C 0%

Calcium 0% • Iron 10%

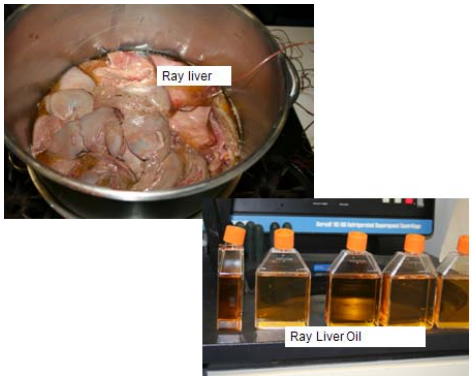
*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories	2,000	2,500
Total Fat	Less Than	65g	80g
Saturated Fat	Less Than	20g	25g
Cholesterol	Less Than	300mg	300 mg
Sodium	Less Than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Ray liver oil:

Ray liver samples from June and September were sent to a certified lab to evaluate suitable volume of oil in the livers and the fatty acid profiles. These samples represented liver conditions (quality) at the beginning of their residency here in the Bay and after they have been feeding on natural prey items in the Bay. The results of these comparative determinations are listed below. A large difference in the amount of fat between liver samples was found, 39% in May and 59% in September. Further, there maintained an observed difference in the amount and type of Omega 3 (*w*3) content between the samples, with the May sample containing almost all DHA (docosahexaenoic acid) while EPA (eicosapentaenoic acid) was significantly increased in the September sample. These polyunsaturated long-chained fatty acids cannot be synthesized by the human body, and are therefore essential fatty acids needed for normal human metabolism.



Ray Liver Fatty Acid Profiles:

May 2007 Sample (39% Fat)

Fatty Acid Profile	C# : Dbl. Bonds	Relative Basis %	Fat (B & D) Basis %	Sample Basis %
Myristic	14:0	0.59	0.45	0.18
Myristoleic	14:1	0.08	0.06	0.02
Pentadecanoic	15:0	0.53	0.41	0.16
Palmitic	16:0	18.50	14.11	5.67
Palmitoleic	16:1ω7	8.28	6.32	2.54
Hexadecatetraenoic	16:4	0.88	0.67	0.27
Heptadecanoic	17:0	0.86	0.65	0.26
Stearic	18:0	7.07	5.39	2.17
Oleic	18:1ω9	11.27	8.59	3.45
Oleic	18:1ω7	2.38	1.81	0.73
Linoleic	18:2ω6	0.59	0.45	0.18
Linolenic	18:3ω6	0.90	0.69	0.28
Linolenic	18:3ω3	0.11	0.08	0.03
Octadecatetraenoic	18:4ω3	0.19	0.15	0.06
Arachidic	20:0	0.30	0.23	0.09
Eicosanoic	20:1ω11	2.44	1.86	0.75
Eicosanoic	20:1ω9	1.02	0.78	0.31
Eicosanoic	20:1ω7	2.48	1.89	0.76
Eicosadienoic	20:2ω6	0.92	0.70	0.28
Eicosatrienoic	20:3ω6	0.22	0.17	0.07
Aracidonic	20:4ω6	1.94	1.48	0.60
Aracidonic	20:4ω3	0.09	0.07	0.03
Eicosapentaenoic	20:5ω3	1.28	0.97	0.39
Erucic	22:1ω11	0.12	0.09	0.04
Uncosapentaenoic	21:5ω3	0.44	0.34	0.14
Docosatetraenoic	22:4ω6	1.95	1.48	0.60
Docosapentaenoic	22:5ω6	3.44	2.63	1.06
Docosapentaenoic	22:5ω3	2.86	2.18	0.88
Docosahexaenoic	22:6ω3	21.18	16.14	6.49
Other	n/a	7.08	5.40	2.17
		100.00	76.24	30.66
	Total % ω3	26.15	19.94	8.02
	Total % ω6	9.95	7.59	3.05

September 2007 Sample (59% Fat)

Fatty Acid Profile	C# : Dbl. Bonds	Relative Basis %	Fat (B & D) Basis %	Sample Basis %
Myristic	14:0	2.47	1.99	1.19
Myristoleic	14:1	0.23	0.18	0.11
Pentadecanoic	15:0	0.73	0.59	0.35
Palmitic	16:0	18.26	14.70	8.80
Palmitoleic	16:1ω7	8.76	7.05	4.22
Hexadecadienoic	16:2	0.40	0.32	0.19
Hexadecatrienoic	16:3	0.21	0.17	0.10
Hexadecatetraenoic	16:4	0.86	0.69	0.41
Heptadecanoic	17:0	1.02	0.82	0.49
Stearic	18:0	5.36	4.32	2.58
Oleic	18:1ω9	9.18	7.39	4.42
Oleic	18:1ω7	3.16	2.54	1.52
Linoleic	18:2ω6	1.44	1.16	0.69
Linolenic	18:3ω6	0.55	0.44	0.26
Linolenic	18:3ω3	1.03	0.83	0.50
Octadecatetraenoic	18:4ω3	1.87	1.50	0.90
Arachidic	20:0	0.18	0.14	0.08
Eicosanoic	20:1ω11	1.57	1.26	0.76
Eicosanoic	20:1ω9	0.75	0.60	0.36
Eicosanoic	20:1ω7	1.84	1.48	0.88
Eicosadienoic	20:2ω6	0.62	0.50	0.30
Eicosatrienoic	20:3ω6	0.17	0.14	0.08
Eicosatrienoic	20:3ω3	0.14	0.12	0.07
Aracidonic	20:4ω6	1.47	1.18	0.71
Aracidonic	20:4ω3	0.89	0.72	0.43
Eicosapentaenoic	20:5ω3	6.05	4.87	2.92
Uncosapentaenoic	21:5ω3	0.27	0.21	0.13
Docosatetraenoic	22:4ω6	0.50	0.40	0.24
Docosapentaenoic	22:5ω6	1.54	1.24	0.74
Docosapentaenoic	22:5ω3	2.31	1.86	1.11
Docosahexaenoic	22:6ω3	20.98	16.89	10.11
Nervonic	24:1ω9	0.20	0.16	0.10
Other	n/a	5.02	4.04	2.42
		100.00	80.52	48.18
	Total % ω3	33.54	27.00	16.16
	Total % ω6	6.28	5.05	3.02

Ray Liver Oil

The oil from 5 ray livers were processed at VIMS through a cooking processes which separates liver oil from liver solids. The oil recovered was thoroughly refined (removal of particulates and any water) by filtration and centrifugation. The resulting oil was shipped to the Canadian Institute of Fisheries Technology at Dalhousie University Halifax, NS for fatty acid methyl esters lipid class profiles. The weight % fatty acid composition is reported in Table 1 and the lipid class profiles are presented in Table 2. The results were positive for lipid content, in that they were all triglyceride and there was no other component that might be an issue. Further, the free fatty acids were low so the oil was fresh. However, the fatty acid profile was disappointing with the amount of Omega 3 and 6 represented at levels lower than observed in previous tests on the whole livers. The oil sample did not include total lipids (phospholipids which were extracted during the oil production method). Further research into processing ray oil while retaining these phospholipids needs to be addressed.

Lipid class composition of cow nose ray liver oil.

Lipid Class	Weight Percent (%)
Triacylglycerol	98.7
Free Fatty Acid	0.9
Polar Lipids	0.4

Table 2. Fatty acid profile of cow nose ray liver oil (weight % total fatty acids).

Fatty acid	% total
12:0	0.02
13:0	0.01
i-14:0	0.01
14:0	1.32
14:1n-9	0.13
14:1n-7	0.03
14:1n-5	0.11
i-15:0	0.13
ai-15:0	0.04
15:0	1.01
15:1n-8	0.01
15:1n-6	0.03
i-16:0	0.40
16:0	18.82
16:1n-11	0.41
16:1n-9	0.38
16:1n-7	11.17
16:1n-5	0.14
17:1(a)	0.02
i-17:0	1.68
16:2n-6	0.04

ai-17:0	1.10
17:1(b)	0.28
16:2n-4	0.13
17:0	1.02
16:3n-4	0.09
17:1	0.65
16:3n-3	0.02
16:4n-3	0.54
16:4n-1	0.05
18:0	7.53
18:1n-13	0.39
18:1n-11	0.11
18:1n-9	15.94
18:1n-7	2.22
18:1n-5	0.13
18:2d5,11	0.11
18:2n-7	0.08
18:2n-6	0.84
i-19:0	0.49
18:2n-4	0.11
18:3n-6	0.10
18:3n-4	0.13
18:3n-3	0.60
18:3n-1	0.11
18:4n-3	0.71
18:4n-1	0.02
20:0	0.26
20:1n-11	1.80
20:1n-9	0.89
20:1n-7	1.65
20:2NMID1	0.10
20:2n-9	0.01
20:2NMID2	0.00
20:2n-6	0.76
20:3NMIT	0.05
20:3n-6	0.23
20:4n-6	2.54
20:3n-3	0.12
20:4n-3	0.43
20:5n-3	4.32
22:0	0.03
22:1n-11	0.14
22:1n-9	0.13
22:1n-7	0.15
22:2NMID1	1.47
22:2NMID2	0.37
22:3NMIT	0.00
22:2n-6	0.06
21:5n-3	0.29
unknown	0.57
22:4n-6	1.15
22:5n-6	1.17
22:4n-3	0.04
22:5n-3	2.03
22:6n-3	9.79
24:1	0.06

Ray Liver Oil Heavy Metals determination (note levels reported in part per billion)

All heavy metals tested were below action levels.

Cadmium	<10 PPB
Arsenic	26600.0 PPB
Lead	<10 PPB
Mercury	11.2 PPB
Selenium	69.7 PPB

Ray bait

Cownose ray was tested as bait in the Virginia whelk (conch) fishery as an alternative to the increasingly regulated horseshoe crab. Initial trials testing attraction capacity of ray to channeled whelk was initially performed in shore-side flume tanks at VIMS. One pound section of fresh cownose ray (cnr) wing flesh was placed 1 meter from 4 acclimated whelks within the holding tank. Water flow within the tank was stopped once ray was placed in tank. Three trials were performed at 2 different water temperatures, 26 and 17^0C. Stimulation of whelk (extension of syphon), movement to bait, and determination of active feeding once on bait were observed.

Trial 1; whelk stimulated w/in 2 min., on bait w/in 7 min., but did not feed (26^0C)

Trial 2; whelk stimulated w/in 2 min., first whelk on bait @ 5 min. and fed (16^0C)

Trial 3; whelk stimulated w/in 5 min., first whelk on bait @ 25 min., 4 on w/in 45 min., all fed once on bait (17^0C)

These trials provided conclusive results that cownose ray flesh does attract channeled whelk and that whelk will scavenge on ray flesh. Further, though attracted to the ray at higher temperature water, channeled whelk was observed not to actively feed on the ray flesh. Similar trials conducted at 26^0C using horseshoe crab (hsc) gave similar results, with whelk attracted to crab but not actively feeding on the crab. Water temperature may play a significant role in bait effectiveness.

Results from the shore-side tests provided impetus for testing cownose ray within the commercial whelk trap fishery. Two fishing trials were performed using cownose ray as bait; off-shore fishery in June, and near shore fishery in December. Cownose ray chunks (~1.5 pound) were cut from frozen whole rays (see picture) for placement within conch pots fitted with bait bags. Testing consisted of alternating control (half female horseshoe crab) traps and treatment traps (cownose ray) within a line of 50 traps (see picture of traps). This resulted in each line of traps having equal test and control groups. The density of whelk may vary greatly over the area covered by a given line, which could cause a bias as to where the traps are located along the line. By alternating the control with the treatment traps along the line this potential bias was minimized. Soak periods for this study 6 days. Upon retrieval of the traps the number of whelk per trap was recorded.

Cownose ray cut into 1 pound chunks for use as bait in the whelk fishery.

Commercial whelk (conch) traps.

Summary results of bait testing on commercial vessel:

Trial 1: string of 34 traps, December near shore

hsc; 194 conch/17 traps= 11.4/trap

cnr; 117 conch/17 traps= 6.8/trap

Trail 2: string of 10 traps, June off shore

hsc; 59 conch/4 traps= 14.3/trap

cnr; 22 conch/4 traps= 5.5/trap

Results demonstrated that cownose ray as whelk bait caught fewer whelks than horseshoe crab (0.59 and 0.38 catch rate for December and June trials respectively). Although catch was

reduced by approximately half, cownose ray represented the most effective alternative bait tested to-date to replace hsc in the whelk fishery. See below.

Alternative bait trials:

Green crab (from New England);	5.0 whelk/trap	Hsc: 24.5 whelk/trap
Ribbed mussel (local);	0.8 whelk/trap	Hsc: 16.0 whelk/trap
Hard clam (M. mercenaria);	10.0 whelk/trap	Hsc: 30.6 whelk/trap
Surf clam (S. solidissima);	13.2 whelk/trap	Hsc: 35.7 whelk/trap
Shrimp heads;	0.6 whelk/trap	Hsc: 37.6 whelk/trap
Knobby whelk (crushed);	2.5 whelk/trap	Hsc: 18.5 whelks/trap
Cow/Bull hide;	0.0 whelk/trap	Hsc 37.7 whelk/trap

HSC Hemolymph/surf clam processing waste/gelatin chub;

Formed chub: 0.27 whelk/trap Hsc: 25.7 whelk/trap

<u>Ray leather</u>

Though the species used in Asia was not similar to cownose ray skin, domestic processing of cownose ray skin was attempted. The skin from cownose ray, both dorsal and ventral sides, were removed from fresh cownose rays, scrapped to remove all muscle attached, salted, then shipped to American Tanning and Leather Company, Griffi, GA for skin product evaluation. The skin from the back of the ray could not consistently be removed intact as a whole, large piece (which is more desirable) without holes resulting due to the thin nature of skin/connective tissue associated with the ray's backbone running down the center. Due to practical time and labor costs of removing the skin from a ray, smaller (less desirable) rectangular pieces of skin were processed from the wings during production of fillets for ray flesh markets. The skin was removed by fish cutters using fillet knives, and scrapped to remove adhering flesh by using a dull scrapping blade. Skins were then salted using a fine grain mixing salt and applied generously (1/2 to 1 inch thick) and rubbed into all parts of the skin. Skins were then layered in a bed of salt, wrapped within butcher-paper and left for 5 days to facilitate moisture removal. Skins were then packed in new salt and shipped to tanner for processing into leather.

The resulting tanned ray skin was thin, soft, and not of high durability (pictures). The black color on some skins was the result of processing with a dye. Amtan had no experience with tanning ray skin, however, there cost estimation for processing ray skin to leather would be similar to that for alligator skin processing, approximately $6.30/cm. Further comments from Amtan were; “for the moment we don’t have any interest, the skins are too small and can’t have much use for our clients. We just aren’t set up to handle things of low value, labor costs are increasing, and fuel price increases have skyrocketed our chemical costs”.

Ray skin removed from ray body

Salting skins removed from ray wings

Leather produced from cownose ray skin.

Ray as dog food

Testing for thiaminase in cownose ray was scheduled to take place, a necessary step in evaluating its use in dog food formulation; however, a suitable grinder to reduce whole rays down to homogenate as needed for testing protocol could not be found within industry or academia. By the time an alternative grinder (small grinder not suited for intended processing) was found source of ray was not available and sample preparations for testing was not performed. Thiaminase is an enzyme which destroys thiamin (Vitamin B1) a critical component of neural/muscular function in animals. It is found naturally in many fish species and its use in pet food formulation is avoided.

Culinary traits of Cownose ray

Processing cownose ray meat from the body provides several different cuts, each with distinctive characteristic. In the attempt to establish the most favorable value for cownose ray as a seafood commodity, raw, minimally processed ray meat destined to white table-cloth restaurants was targeted initially. The muscle rendered from cownose ray is very low in fat. This aspect makes it bland tasting in nature, and therefore appealing to chefs who view such protein source as a vehicle for creative flavor profiling. The low fat characteristic also warrants concern, or thought of product form for preparation and final plate presentation, where over-cooking can result quickly in thin cuts and unequal cooking in thick cuts. (Note: A lot of people I have meet during this study who cooked ray after catching it themselves did not like it, with the common complaint that when they cooked a wing on the grill, it would turn to leather on the outside while still raw inside) Like most lean game species (venison, rabbit, etc.), ray meat will cook quickly under high heat. After removal of the wings from the body of the ray by cutting along and through the hour-glass margin observed along the dorsal side of the ray on each side of the backbone (outline of muscle mass), the two severed wings can either be further cut into

fillets or steaks. Fillets (4, top and bottom from both wings) are produced by separating the flesh from the cartilage that runs centrally along the length of the wing. The resulting fillets will be unequal in thickness. The thickest part of the fillet (closest to the body) provides for a loin cut. With the loin cut removed, the resulting flesh comprises the fillet, which is still unequal in thickness. Slicing half-inch thick strips along a slight bias perpendicular to the fillet (see picture below), separates muscle bundles and allows for uniform marinating and cooking, while also providing unique plate presentations. Steaks are produced from wings by cutting down through the wings perpendicular to the wing cartilage which separates the top and bottom fillets.

Hour-glass profile to cut along when removing wings (top fillet removed)

Fillet being removed from wing cartilage

Ray wing profile showing cartilage separating fillets

Ray fillets sliced thinly on a bias

Marketing Trials

Marketing trials using fresh ray were conducted throughout the summer and frozen ray during fall and winter months. The various ray market forms---wings, fillets, loins---were distributed from the processing plant to chefs around the state for culinary evaluations. A ray fact sheet, recipes and a survey accompanied each delivery of ray. Chefs were asked to work with the ray, test preparation methods, and if so desired, include it on their menu. Fifty-four restaurants participated, out of which 35 restaurants had positive responses and 12 had negative responses. Seven restaurants reordered product to include on their menu. From

these efforts, 41 chefs indicated that they were interested more education on the ray, including menuing, plate presentation and wait staff training. From these trials, it became obvious that since ray is a new product and unlike any other seafood item, a large amount of time and money has to be spent on product education and personal selling effort if this product is to have a successful introduction.

Four seafood and broad line distributors tested ray within their company with a mixed response. They were not asked to test product with their restaurant customers because more education and training would be required on such a new seafood product.

Through the Virginia Marine Products Board, working with Chef John Maxwell, seventeen presentations were conducted for chefs and consumers with approximately one thousand attending. These taste tests indicated a 95% positive response rate.

Ray sampling trial

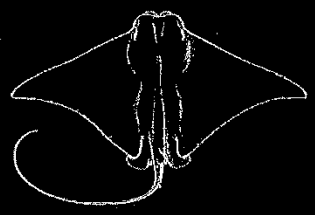
54 Restaurants in the state participated.
35 Restaurants had positive responses.
12 Restaurants had negative responses.
3 Had no response because of chef relocation.
7 Restaurants requested a second order for promoting purposes.
41 Chefs were interested in attending a Seminar on menuing, plate presentation and training wait staff to sell ray.

1 Food Service Distributor sampled
Comments: Looked at product, cooked some up and tried it.
"Tasted very good. Let me know when you have ample supplies"

Marketing publications

Through the VMPB, marketing information was produced using nutritional and processing information from this project to promote the use of cownose ray products. The logo for Chesapeake Ray was published, followed by information on cuts taken from the ray wings, nutritional fact sheet, and recipes (below).

Marketing Logo for cownose ray



Chesapeake Ray: Rhinoptera Bonasus

Market Forms:.....Fresh loins, wing chunks, wings, Frozen loins, wing chunks, wings

Size:.....Large ray.....20-40 pounds
Small ray.....10-15 pounds

Taste and Texture:.....Tender, meat with beefy flavor

Seasonality:.....Found in the Chesapeake Bay and East Coast waters from May till late September

Nutritional Value:.....Per 3 oz. serving
Moisture.....76.48
Protein..... 23.40
Fat..... 0.4

Substitutability:.....Veal, Flank Steak

Habitat:.....Western Atlantic, Southern New England to northern Florida throughout the Gulf of Mexico, migrating to Venezuela and Brazil.

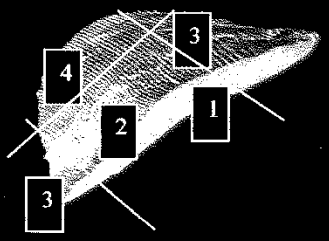
Folklore:.....In 1608, Captain John Smith, and East coast settler and explorer, learned about the nature of a Chesapeake Ray. While Smith was spearing a ray with his sword near the Rappahannock River, the ray defended itself by striking Smith in the shoulder with its barb, located on the base of its tail. The pain was so terrible that the crew was convinced Smith was dying, so they dug a grave for him. But he overcame the pain and felt well enough that evening to eat the ray for supper. The place where this happened is still known as Stingray Point, located in Deltaville, VA.

Harvesting:.....Chesapeake ray are harvested by day boats using pound and gill nets.

Quality Statement:.....Virginia's waters and products are regulated by federal and state agencies including the FDA, the Virginia Department of Health, the Virginia Department of Agriculture and Consumer Services, the Virginia Department of Environmental Quality, and the Virginia Marine Resources Commission, insuring that only safe wholesome seafood reaches our customers.

ChesapeakeRAY

Chesapeake Ray Filet Cuts and How They can be Utilized



This filet can be used in its entirety. While there is no discernable flavor difference between the parts of the filet, there are slight mouth-feel differences. The area in the thickest part of the filet tends to have less fiber than the thinner tapered ends and therefore, is somewhat tenderer. The difference is slight, however.

1. The thickest part of the filet has several best use purposes.
   a. Paillards cut from the thick part, across the grain, can be pounded and treated as piccatta, schnitzel, or cutlet. Cut along the grain and pounded also produces a very tender product useful as schnitzel or cutlet.
   b. Larger cuts from this area can be grilled, broiled, or sautéed as steaks. Because of the extremely low fat content (less than .5%) oil based marinades, larding, or barding treatments can add flavor.
   c. Very thin, cross grain cuts can be treated as sashimi or as carpaccio.

2. Cuts from the middle portion.
   a. Treated as in b. above, cuts from this area are excellent steaks. These thinner steaks are suitable for recipes calling for medallions. They can be cooked quickly over medium high heat to produce nicely caramelized pan steaks and the remaining fond produces good pan sauces.
   b. Cuts from this region are excellent for sashimi or carpaccio.

3. Cuts along the grain.
   a. Thin strips from any section can be breaded and fried as "stingers".
   b. Pounded, paillards cut with the grain are tender and retain their shape when cooked.

4. Cuts from the thinner, tapered portions and scrap.
   a. Cuts from this area can be minced and seasoned as in "tartar".
   b. Ground, ray can be used very successfully as stuffing, meat balls, or forcemeat. Due to the very low fat content, some additional fat may be needed to help develop the flavor or to assist in binding the meat. For example, egg yolks can aid meatball recipes. Minced bacon or fatback can complement stuffing and fillings.
   c. For hamburger treatments, some additional structure is needed to establish a more resistant mouth-feel and to help hold the burger together during cooking.

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Recipes for Cownose Ray (Rhinoptera bonasus)

Chesapeake Ray Fajitas

1 ½ lbs. Chesapeake Ray filets, skinned
2 Tablespoons garlic, minced
2 teaspoons ground cumin
2 Tablespoons lemon juice
1 Tablespoon lime juice
¼ cup vegetable oil, plus 2 Tablespoons
1 cup sweet red pepper
1 cup onion
¼ cup julienned jalapeno or poblano pepper
1 lime, cut in wedges
1 teaspoon oregano
1 Tablespoon garlic minced
1 tablespoon fresh cilantro, minced
Salt and pepper

Combine 2 tablespoons minced garlic, the cumin, lemon and lime juice and ¼ cup vegetable oil. Skin ray filets and slice into strips. Season ray with salt and pepper. Cover in the marinade and let sit in refrigerator for about 1 hour. Heat skillet to medium high heat and quickly sear ray strips on both sides. Ray should be medium rare; do not overcook! Remove from skillet and reserve in a warm oven. Add additional garlic to pan and sauté for one minute. Add pepper and onions and cook until they are soft. Add wedges of lime and heat through. Serve ray and vegetables with soft flour tortillas and condiments such as sour cream, guacamole, and salsa.

—recipe adapted from original version developed by Chef John Maxwell, Richmond VA

Ray Kabobs

1 lb. ray filets
2 green peppers, seeded and cut into 1-1/2-inch chunks
Salt and Pepper to taste
½ cup bottled barbecue sauce
16 boiling onions
1 ½ t. lemon juice
16 slices bacon
16 pineapple chunks
16 cherry tomatoes

Parboil onions in boiling water, covered for 5 minutes, adding green pepper chunks at the last 2 minutes of cooking. Drain and peel onions. Cut ray into 1-inch cubes; pat dry. Sprinkle ray with lemon juice, salt and pepper. Partially cook bacon; drain. Wrap 1 slice bacon around each ray chunk; secure with wooden picks. Thread wrapped ray, onions, pepper chunks and pineapple alternately on eight skewers, ending with tomatoes. Grill over medium-hot coals for about 15 minutes, turning and basting often with your favorite barbecue sauce. Makes 4 servings.

Baked Devilfish

2 lbs.of ray fillets
3 c. soft bread crumbs
1 1/2 T. grated Parmesan cheese
1/2 t. salt
1/2 c. melted butter, divided
1 1/2 T. Worcestershire sauce
1/2 t. prepared mustard
Preheat oven to 325 F.

In medium bowl mix bread crumbs, Parmesan cheese, salt, 1/4 cup of butter, Worcestershire sauce and mustard. Place fish fillets in a single layer in a greased, shallow baking pan. Spoon bread crumb mixture evenly over fillets. Dribble remaining 1/4 cup of butter over bread crumbs. Add water to barely cover bottom of pan (about 1/2 cup). Cover with greased foil.

Bake until fish flakes easily when tested with a fork (about 15 minutes). Remove cover. Lightly brown under hot broiler. For extra zip, use Dijon-style mustard. Makes 4–6 servings.

Ray Creole

1 lb. ray fillets, cut into 1-inch chunks
4 cloves chopped garlic
1/3 c. flour
1 c. hot water
½ c. chopped green onions, including tops
¼ c. chopped green pepper
½ c. chopped parsley
1/3 c. vegetable oil
1 ½ t. salt
Dash cayenne pepper
½ t. thyme
2 whole bay leaves
1 lemon slice
1 can (8 oz.) tomato sauce
Cooked rice

Prepare roux by heating oil in large skillet and blending in flour over medium heat, stirring constantly until brown. Add water gradually and cook until thick and smooth. Add remaining ingredients except rice. Cook and simmer for 15 minutes. Remove bay leaves and serve over cooked rice. Makes 4 to 6 servings.