Salt Iodization in Haiti: Challenges to Improving Salt Production Quality and Recommendations for Pursuing Iodization

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One thing I was hoping to work on for my MPH capstone is a problem that I felt strongly about and would pursue regardless of there being an MPH capstone requirement. I didn’t know that iodine deficiency would become as personal to me as it is, but given the global impact of iodine deficiency disorders, I think my fixation matches the magnitude of the issue. I hope that countries such as Haiti will be able to make headway on the burden of iodine deficiency and reap benefits many of us can afford to take for granted.
I would first like to thank the Johns Hopkins Bloomberg School of Public Health and Dr Keith West for the opportunity to pursue this research, and for all the support that was necessary to continue. My friend and fellow classmate Jane Andrews has been indispensable with input and dedication. Additionally, I would like to thank Amber Lynn Munger and the Article 29 Organization, for what she has done for this project and the life lessons that came through the process.

Also, I would like to thank Magalie Personna, for her input and who made herself a friend to us; Demeter Russafov and Darline Raphael, for their input with our research; and Remle Stubbs-Dame and Laalitha Surapaneni, our classmates who were with us in Haiti when the earthquake struck. I also want to say thank you in particular to the Micronutrient Initiative and Mohan Rallapalli. His guidance and expertise were invaluable.
### Abbreviations

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<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>AMURT</td>
<td>Ananda Marga Universal Relief Team</td>
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<td>AOPS</td>
<td>Association des Œuvres Privées de Santé</td>
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<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
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<td>FAO</td>
<td>Food and Agricultural Organization of the United Nations</td>
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<td>FDA</td>
<td>Food and Drug Administration</td>
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<td>HDPE</td>
<td>High-density polyethylene</td>
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<td>ICCIDD</td>
<td>International Council for Control of IDD</td>
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<td>IDD</td>
<td>Iodine deficiency disorders</td>
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<td>LDPE</td>
<td>Low-density polyethylene</td>
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<td>MI</td>
<td>Micronutrient Initiative</td>
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<tr>
<td>MINUSTAH</td>
<td>United Nations Stabilization Mission in Haiti</td>
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<td>MARNDR</td>
<td>Ministry of Agriculture, Natural Resources, and Rural Development</td>
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<td>MSPP</td>
<td>Ministry of Population and Public Health</td>
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<td>PAHO</td>
<td>Pan American Health Organization</td>
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<td>ppm</td>
<td>Parts per million</td>
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<tr>
<td>µg</td>
<td>Microgram</td>
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<tr>
<td>UND</td>
<td>University of Notre Dame</td>
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<td>UNICEF</td>
<td>United Nation’s Children Fund</td>
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<tr>
<td>USAID</td>
<td>US Agency for International Development</td>
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<td>USI</td>
<td>Universal Salt Iodization</td>
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<td>WFP</td>
<td>World Food Program</td>
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I. Executive Summary

Haiti is a country struggling to decrease the burden of iodine deficiency diseases and provide iodized salt to the population. One of the greatest challenges to providing iodized salt has been the need to increase the quality of domestically produced salt, so that the purity is more effective for iodization. Experts have recommended a transition to using modern serial pond production that would result in the desired improvement in salt quality. This is seen as necessary step to the sustainable reduction of iodine deficiency disorders for the country.

While there is interest among producers in converting to this new method of salt production, salt producers perceive several barriers to converting to this new method. Based on a review of initiatives to date, along with an assessment among salt producers in Commune Anse Rouge, it was observed that salt producers lacked adequate economic incentives to convert their ponds, with many that also believed they did not meet necessary land requirements to adopt the new production method. It is suggested that producers be provided with additional training courses and financial assistance, either in the form of credit assistance or subsidy, to catalyze this transition process.

Also, it appeared that the producers’ knowledge of iodine deficiency and iodization methods was lacking. Additional education would be needed for any future iodization initiatives, and could also build enthusiasm for transition to modern pond production. Additional considerations are offered for salt production and iodization based on current challenges.
II. Introduction

Over the past twenty years the consequences of iodine deficiency have gained the attention of both academic and political minds. Adequate iodine intake is now acknowledged as a priority outside of just public health and nutrition circles. For example, In 1993 a study by the World Bank published an estimate, that for each dollar spent on iodine deficiency prevention there is a gain of 28 dollars in productivity (1). In 2008 the Copenhagen Consensus did the same thing, citing statistics such as a 30:1 benefit to cost ratio given a 3% annual discount rate for interventions for iodine deficiency disorders, or IDD (2). In the past there was a large volume of research documenting the effects of treating general malnutrition, on individuals and societies. However, with increasing research that specifically examines the effects of iodine deficiency - on individuals and on societies - it appears that the benefits of addressing iodine deficiency alone can be dramatic, even transformative in many places.

In 1990, the World Health Assembly established the goal to eliminate iodine deficiency as a public health problem (3). An ambitious mid-decade commitment to eliminate iodine deficiency disorders (IDD) by the year 2000 resulted in much progress (4). Household iodine consumption increased from less than 20 percent before 1980 to almost 70 percent at the end of the century (5). In 2002 the UN General Assembly tried again, resolving to achieve the sustainable elimination of IDD by 2005 (3). Now in 2010, despite piecemeal progress, comprehensive success is still at a distance. With continued diligence, however, the World Health Assembly
adopted a resolution in 2005 to report on the global status of IDD every three years.

Much has been done. With the establishment of the ICCIDD, the UNICEF-WHO Joint Committee and the Iodine Network, the prioritization of universal salt iodization, along with numerous scientific studies, models for intervention, and resource investment, the global community has made much progress in reducing IDD. However, in many countries such as Haiti, there is still a lot to be done before the elimination of IDD becomes reality.

This paper was written to support the ongoing work and initiatives for the reduction of IDD in Haiti, a country that began iodine interventions more than a decade ago but is struggling to achieve population impact. Given the increased stress facing the government as a result of the January 12th 2010 earthquake, any long-term investment such as for reducing iodine deficiency disorder will need stronger support to find traction with decision makers. However, with a clear look at the situation, the importance of the work will be understood.

**Physical need for iodine**

Iodine is an essential component for the health and well being of individuals at every stage of life. The values for recommended iodine intake vary according to age, and also for females according to pregnancy and lactation status (for more information see Appendix A). Iodine is necessary for the thyroid to produce thyroid hormone; the inadequate consumption of iodine leads to the decreased production of thyroid hormone. Health problems due to iodine deficiency are primarily due to
the inadequate levels of thyroid hormone in the body. While other factors besides iodine can disrupt the normal functioning of the thyroid\(^1\), iodine deficiency is much more commonly the cause of thyroid dysfunction. The spectrum of iodine deficiency disorders includes many other things besides goiter and hypothyroidism. In 1983 Basil Hetzel actually proposed use of the term “iodine deficiency disorders” to replace “goiter”, in the hopes that people would begin to understand that the effects of iodine deficiency extend beyond those of just goiter. The list is long, but consequences also include an increased susceptibility to radiation, impaired mental function, delayed physical development, short stature, and the increased chance of spontaneous abortions, stillbirths, and congenital anomalies (7). For more information regarding iodine in infants and newborns, see Appendix B.

Aside from starvation, iodine deficiency has been recognized as the most frequent nutritional cause of mental retardation and cerebral palsy (6). There is also some evidence that iodine deficiency may be related to attention deficit and hyperactivity disorder (8). The most extreme form of impaired development is cretinism, which can be seen when daily intake is below 20 µg/day, and is characterized by mental deficiency, deaf mutism, and spastic diplegia, as well as other neurological deficits (7).

Figure 1 is an illustration of the “IDD Iceberg” which helps to show the distribution of disorders resulting from iodine deficiency (10). While the effects of

\(^1\) Some of these include selenium deficiency, goitrogens in food, or other endocrine abnormalities (6)

\(^2\) In order to prevent cretinism, interventions to correct iodine deficiency need to occur very early in pregnancy, with mid-gestation at the very latest. Although small
iodine deficiency are very apparent in severely-deficient individuals with cretinism, the most common forms of IDD and neurologic damage may not be apparent unless specifically tested (11).

Figure 1. The IDD Iceberg

**Iodine and intelligence**

In humans, optimal neurocognitive development *depends on* the body having adequate levels of thyroid hormone, which cannot be made unless there is adequate iodine intake. As mentioned, while effects from iodine deficiency are not as extreme as those seen in cretinism and may not result in obvious neurological deficit, iodine deficiency can be responsible for reduced cognitive capacity. There are two meta-analyses revealing that people living in areas with iodine deficiency have up to approximately 13 fewer IQ points than those in comparable non-deficient areas (12,13).

improvements to the central nervous system may still be possible with the repletion of iodine, in general the damage is irreversible (6,9).
Interestingly, the renowned researcher James Flynn has described how in many countries the average IQ seems to be increasing by 3 points each decade (14). While there are several possible explanations, some believe that improved nutrition during gestation and infancy is the most likely factor that has contributed to the rise in Intelligence Quotients and Development Quotients. In the United States, the observed “Flynn effect” has been seen within the past century over the same time that great improvements were made in the country’s iodine nutrition. In 1918 a study of men registering for the military revealed a goiter rate of 30 percent (15). It wasn’t until 1924 that salt iodization first began in the US (16), and then in 1949 that iodized salt consumption accelerated when a public health campaign began (in that year, still just one-third of the salt in the US was being iodized) (17). Flynn observed that between 1932 and 1978, white Americans experienced an average increase of 14 IQ points (18). Based on what we know about iodine nutrition, it is possible that the improvement in iodine nutrition during these years may have played a role.

As discussed, it has been found that the difference between adequate and deficient iodine status can lead to an IQ loss of almost one standard deviation in a given individual. However, when seen as a collective impact on a deficient community, these changes can be crippling, leading to decreased educability and work productivity as well as impaired social and economic development (19). These effects in turn could then reduce the benefit of other potential public health or development initiatives. Sadly, there are iodine deficient communities that have been described with very sluggish characteristics:
“Indeed in an iodine-deficient population, everybody may seem to be slow and rather sleepy. The quality of life is poor, ambition is blunted, and the community becomes trapped in a self-perpetuating cycle. Even the domestic animals, such as village dogs, are affected. Livestock productivity is also dramatically reduced.” (20)

However, after the correction of iodine deficiency in the community, there are reports of visible improvements and a ‘coming to life’ in the people. Observations have included improved learning in children, improved work performance in adults, along with a overall transformation in a community’s outlook.

There is a story of a village of 1200 people in China named Jixian, where it was found that 65% of the people had goiter. Jixian was said to be a depressed community with a low income, where many had a sense of hopeless inadequacy. Jixian had been known as the “Village of Idiots,” as it was estimated that around ten percent of the village had cretinism. Nobody wanted to marry the men in the village. In 1978 an iodized salt program began in the village, followed by other interventions to increase the iodine intake of the community. Not even a few years after, per capita income doubled within a period of three years. Additionally, the village school’s performance went from last in the district (14th) to third, with the school’s failure rate improving to 2% from previously being greater than 50%. In addition to the increased wealth and improved academic performance, more than forty girls came from neighboring villages to be brides after this time (21).

There is another story of the village Kiga in Iran, where one study showed 100% of the children between 6 and 18 years were found to have goiter. Just 4
months after receiving an iodized oil injection in 1989, people from other villages could tell the difference and began asking for the “intelligence shot” (22).

While the known statistics for iodine deficiency in Haiti do not suggest that it is filled with many communities such as Jixian or Kiga, the rates of iodine deficiency in the country should be a concern to those working in any field of health or development.

**Global statistics on iodine deficiency**

On a worldwide basis iodine deficiency has been called the most preventable cause of brain damage. Every year 38 million newborns are still not protected from iodine deficiency (3). It is estimated that about 31% of the world population still has inadequate iodine intake, with the most affected WHO regions being South-East Asia and Europe, as by number of total affected people (20). Figure 2 shows the fraction of people in each region who are not receiving adequate iodine in their diet. Taken altogether, the Latin American
and Caribbean region has the lowest level of iodine insufficiency. An impressive 85% of the region’s population is consuming adequately iodized salt. With iodine insufficiency in Haiti at *almost 60%*, less than 5 percent of the population is consuming adequately iodized salt (3).
III. Salt and Iodine Deficiency in Haiti

In 2004-2005 the national iodine deficiency rate was estimated to be 58.9\%

\(\text{iii}^{\text{ii}}\). When broken down by population density categories, iodine deficiency rates were measured to be 41.4\% in metropolitan areas, 52.4\% in urban areas, and 72.5\% in rural areas (23). It is estimated that country has a total goiter rate of 12\% (24). However, a 2008 study conducted in a mountainous area found 93\%\textsuperscript{iv} of examined individuals to be iodine deficient based on urinary iodine concentration, with 51\% having goiter, and 20\% being severely deficient (<20 \(\mu\)g/L) (26). It is unknown how many villages or communities may be experiencing rates of deficiency as high as this.

Based on factors such as salt coverage, unprotected infants, and challenges with small-scale salt production, the Iodine Network established a 2005-2010 priority list of countries needing support that included Haiti\textsuperscript{v}. With a population estimated at less than 10 million, there are many countries with greater numbers of iodine deficient individuals. However, given its high deficiency rates and low iodized salt coverage, an estimated 29,000 children are born annually with mental impairment due to iodine deficiency in the country, with a total of 261,000 unprotected children born every year (3,28).  

\(\text{iii}^{\text{ii}}\) as defined by urinary iodine concentration <100ug/L. The most commonly used method to measure iodine deficiency in a population is through spot urinary iodine levels. For more information on measuring deficiency see appendix C.  
\(\text{iv}^{\text{iv}}\) This number is also approximately the same as that measured in a study one decade prior in a school in Leogane (25).  
\(\text{v}^{\text{v}}\) This list also include Bangladesh, Bolivia, Egypt, Ethiopia, Guatemala, Indonesia, Pakistan, Philippines, and Vietnam (27).
IV. Interventions to Reduce IDD

While there are a few countries that do not require public health intervention in order to consume adequate levels of iodine\textsuperscript{vi}, the majority of people in the world require either iodine supplementation or fortification to receive adequate iodine intake. Fortification generally occurs through adding iodine to the public salt supply and is preferred for many reasons. When fortification is unavailable or inadequate, iodine supplementation can be used to reach certain individuals of greater vulnerability.

**Iodine Supplementation**

Iodine supplementation typically comes in the form of oil capsules can be targeted toward pregnant females, women of childbearing age, and children between 7 and 24 months of age. While iodine consumption is important at every age, these are the groups that receive the greatest benefit from proper iodine nutrition\textsuperscript{vii}. This supplementation can be given as a daily oral dose of iodine or also as a single dose of iodized oil every six to 12 months.

\textsuperscript{vi} For example, Japan does not have iodized salt because of the high consumption of seaweed. The country has significantly fewer cases of iodine deficiency and excellent thyroid health (16,29).

\textsuperscript{vii} For children 6 months of age or younger, supplementation should be given through breast milk (20). Also, there is some evidence that supplementation to older children is beneficial. Children in Albania ages 10-12 years who were classified as being moderately deficient in iodine were assigned to receive either 400mg iodized oil supplementation or placebo. Children receiving iodine showed improvements in information processing, motor skills, and visual problem solving (9).
Iodine fortification

Fortification through salt iodization is the most common strategy for reducing iodine deficiency disorders (20). In 1993, universal salt iodization was recommended by WHO and UNICEF Committee on Health Policy as the primary strategy to eliminate IDD (4). Salt is the most commonly utilized vector for iodine supplementation for a number of reasons. The amount of salt consumed by individuals is fairly similar between individuals (typically estimated at 10g daily), and is consumed consistently throughout the year. Also, the addition of iodine to salt does not significantly affect its color, taste, or smell. The cost of iodization is relatively inexpensive, and it is relatively easy to monitor at various levels of production and distribution. In order for salt iodization to be effective, it has to be properly iodized and reach populations at risk (20).

In examining WHO regions and the overall access to iodized salt, there appears to be a strong positive correlation between the proportion having access to iodized salt and the percentage of its population receiving adequate iodine nutrition, as shown in Figure 3. Unfortunately, although Haiti is currently struggling with the highest rates of iodine insufficiency in the
America's region, its consumption of adequately iodized salt has actually decreased, as shown in Figure 4.

USI, or rather Universal Salt Iodization, is defined by the iodization of all salt for humans and livestock. This includes salt used in the food industry (20). While complete iodization of a nation’s salt supply may not always be possible, generally USI is considered successful if greater than 90% of households are using iodized salt. More information is available in appendix D.

Process of salt iodization

In many countries such as Haiti, the consumer supply of salt is produced using solar evaporation. While it is true that seawater naturally has iodine, the iodide content of seawater is very low at 64 µg/kg, or 2.1 mg I/kg NaCl (16), or in other words hardly 10 percent of the recommended levels for iodization\textsuperscript{viii}. Additionally, when salt is produced evaporatively from seawater the amount of

\textsuperscript{viii} The target level for iodization in Haiti is 20-40 ppm, in other words 20-40mg I/kg salt. When discussing levels of salt iodization, it is important to know whether the quantity of iodine is being given in amounts of iodine, potassium iodide, potassium iodate, or another form, as these reference units will all relate to a different amount of iodine.
iodide is actually lower, because the crystallization process leaves the majority of iodine in the water\textsuperscript{ix} remaining after the salt has precipitated (30).

Commonly salt can be iodized with either iodide (I-) or iodate (-IO3) which can be added in the form of either a dry solid in powder form or an aqueous solution as potassium iodide or potassium iodate (20). While most countries in Europe and North America still use potassium iodide for historical reasons (31), WHO recommends use of iodate over iodide because iodate is more stable\textsuperscript{x}. The presence of certain reducing agents in salt can also affect the stability of iodine. This has been shown to play a more important role in iodine loss than other factors such as moisture, heat, and sunlight exposure (36). Ultimately, the best way to avoid reducing agents and minimize iodine loss is through the production of purified salt (32).

In some cases iodine stabilizers can be considered to reduce iodine loss\textsuperscript{xi}. Iodine loss can also be kept to a minimum by using adequate packaging. One study has demonstrated that with good quality small polyethylene bags that are at least 75 microns thick, the loss of iodine over 18 months is less than 10 percent regardless of factors such as climate and granularity of the salt (12).

\textsuperscript{ix} This water is referred to as bittern
\textsuperscript{x} When iodide or iodate interacts with oxidating or reducing agents, respectively, it can change into iodine, which dissipates more quickly from the salt through sublimation. However, iodate is less soluble in water than iodide, and also more resistant to oxidation from exposure to moisture, heat, sunlight, and certain impurities. Interestingly, there have been studies documenting the seasonality of iodine deficiency levels and salt iodine content thought to be related to seasonal variations in humidity (31,32,33,34,35).
\textsuperscript{xi} In the US the FDA has approved the use of dextrose, sodium thiosulfate, sodium bicarbonate, sodium carbonate, and calcium phosphate as buffering agents. Sodium
Determining iodization levels

Ideally, in order to determine the optimal level of iodization, iodine measurements should be taken after the time of iodization and also before consumption. Additional steps can be taken to control the moisture content of the salt through improved production and packaging, which would add to the stability of the iodine in the salt. In some cases – if the quality of the iodized salt is poor, or if the salt is not correctly packaged, or if there is excessive moisture, heat, and contaminants – a greater level of iodine may be lost, perhaps greater than 50%. Under typical circumstances it should be estimated that 20% of the iodine will be lost between iodization site to household, while another 20% will be lost from cooking prior to consumption (34).

Using the estimate that the average salt intake is 10g per person per day, iodine concentration in consumer salt at the point of production should be in the range of 20-40mg\textsuperscript{xii} of iodine per kg of salt, so that the majority of the public receive the recommended iodine intake of around 150ug of iodine per person per day (31,34). Based on this suggestion, it was recommended (37) that if 50 ppm of potassium iodate were added to the salt, this would equal approximately 30 ppm iodine at the point of iodization\textsuperscript{xiii}, a figure directly in the range of WHO hypochlorite has also been shown to be a cheap and effective method to stabilize iodate added to salt (16,36).

\textsuperscript{xii} It is also suggested that if a country uses iodized salt in its processed foods, the iodine content should be toward the lower end of this range. As this does not seem to be the case with Haiti, a higher iodization level may be more appropriate. For comparison, however, the US Food and Drug Administration recommends iodization at a higher level than this, of 46-76 ppm (16).

\textsuperscript{xiii} 1.69 mg potassium iodate contains 1 mg iodine.
recommendations. After factoring in typically assumed losses from transport and cooking, daily intake of iodine would likely be around 150µg\textsuperscript{xiv}.

Monitoring of quantity of iodine being added to salt\textsuperscript{ xv} is important because excessively iodized salt or poorly monitored iodization can lead to problems with iodine excess (38). More information about monitoring salt is given in appendix E.

**Iodine-induced hyperthyroidism**

Even with the appropriate iodization of salt, it is common to see some adverse findings in the initial period following increased iodine consumption. The main health problem that can arise is iodine-induced hyperthyroidism, and less frequently iodine-induced thyroiditis (39,40,41). Individual response to increased iodine intake is variable, but generally most people can consume up to 1000 µg of iodine without experiencing any problem (31). Iodine-induced hyperthyroidism is generally seen more older subjects with existing nodular goiters and those that have had chronic deficiency. It is more commonly seen in supplementation programs versus salt fortification intervention, but can even occur when iodine intake is in the targeted range of 100-200 µg a day\textsuperscript{xvi} (34). Typically the findings are mild and self-limited, with most of the risk focused on cardiovascular concerns. At recommended iodization levels, it is a transitory problem resolving five to 10 years after introducing iodized salt to a deficient population. With any successful iodization program, some cases iodine-induced hyperthyroidism should be seen as

\textsuperscript{xiv} Assuming a 20 percent loss from transport as well as a 20 percent loss from cooking, the exact amount would be 178 µg.

\textsuperscript{ xv} see Appendix D for more information on measuring iodine levels in salt.
an unavoidable problem, but with the benefits of iodization outweighing the problems arising from this temporary condition (40,41,42).

V. Working towards salt iodization in Haiti

Barriers to Adequate Iodine Consumption

In Haiti many potential barriers have been identified to receiving adequate iodine intake and reducing IDD. Some of these have been previously mentioned, but include:

   Household salt washing - Because the quality of domestic salt is typically poor, Haitians commonly wash the salt they buy in the market to remove debris and impurities prior to use. Unfortunately, this practice would wash away any potential iodine that might be added to the salt (43). It is thought that up to 50 percent of the salt volume purchased by consumers may be lost due to routine household washing prior to use.

   Impurities in salt - The traditional method for producing salt consists of allowing a single pond of seawater to evaporate for several weeks until enough salt precipitates to be harvested. This simple method means that the precipitated salt also contains many of the other unwanted minerals found in seawater, such as magnesium sulfate, magnesium chloride, and calcium sulfate. Some of these additional salts can act as reducing factors that increase speed that iodine

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\[ \text{Median urinary iodine values above 200 } \mu\text{g/L (250 } \mu\text{g/L for pregnant women) are not recommended because the risk for iodine-induced hyperthyroidism is higher in areas where iodine deficiency has existed for a long time.} \]
dissipates. More importantly, the magnesium causes the salt to be hygroscopic, which can lead to leaching of iodine that might be added to the salt (44).

*Salt packaging* – Salt produced in Haiti is not packaged in sacks that would allow it to retain iodine (that is, if this were to happen in the future). Either high-density polyethylene bags that have been woven with a continuous film insert, or laminate of low-density polyethylene bags would be best, as both of these options would prevent iodine from leaking out of the bag (20). Salt produced in Haiti is typically distributed in large *breathable* 50-70 kg sacks at harvest sites\textsuperscript{xvii}. Additionally, while appropriately packaging salt into sealed consumer portions could increase the perceived value of the salt as well as help retain iodine, salt is usually apportioned into purchasing volume\textsuperscript{xviii} only once it is sold to the customer.

*Education* – Unsurprisingly, there is lack of general knowledge on the importance of iodine in the public, as there seems to be in perhaps any country. In one unpublished study conducted by a fellow public health student here at Johns Hopkins, Dr Vishnu Laalitha Surapaneni, interviewed 32 individuals in the village of Pont Sondé who were asked about the importance of iodine. Out of everyone, only one who was a nurse was able to identify anything about iodine, which was that it was related to goiter. In addition to household education, it is important for producers to realize the importance of iodization. Iodine education has been

\textsuperscript{xvii} these sacks are can be grouped into a certain number and sold as a *barik*, the creole word for “barrel.” The number of sacks that make up a *barik* can vary by location. To complicate the issue further, some areas apportion the salt by *jakout* and are sold by this unit.

\textsuperscript{xviii} in Creole *Gwo mamit* and *ti mamit* are consumer units for volume measurement used to sell goods such as salt, grains, or other market products. This is derived
repeatedly identified as a necessary barrier to overcome in order to achieve successful salt iodization in the country.

*Environmental* - Many environmental barriers have also contributed to iodine deficiency starting with through the depletion of iodine from the soil. Practices such as overgrazing, tree cutting, and clearing of land for agricultural production can all lead to soil erosion and consequent iodine loss. This may also reduce the iodine content in groundwater and locally grown foods (20). Heavy rainfalls and flooding can also be responsible for the depletion of iodine from the soil (3). These inundations also affect the production of salt by causing damage to salt ponds. Problems of deforestation also exacerbate the problem of flooding. As an interesting example, the tropical storms in 2004 and 2008 caused flooding which also significantly damaged salt ponds throughout the country\textsuperscript{xix}.

*Legislation* - Currently there is no legislation in the country regarding edible salt standards or iodization regulations. Considering that there is no established means to iodize the nation’s supply of salt as of now, this absence perhaps does not affect the penetration of iodized salt into markets. While it has been helpful in some situations, legislation may be seen as a potential tool in the future, but not necessarily a requisite one. For example, salt iodization is still voluntary in the United States\textsuperscript{xx}. Inversely, while Sudan has legislation on salt production and

\textsuperscript{xix} Domestic salt production capacity was set back in 2004 by the flooding due to tropical storm Jeanne. In 2008 four cyclones – Fay, Gustav, Hanna, and Ike – all struck Haiti in the period of approximately one month.

\textsuperscript{xx} This is because in 1949 the Salt Producers’ Association opposed a compulsory iodization bill saying that would be medication by legislation. Instead, iodization

from the French *grosse marmite* and *petite marmite*, respectively. One *gwo mamit* equals six *ti mamit*. 


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iodization, it is not enforced and consequently provides little improvement to the country’s iodine deficiency status (45). Haiti’s domestic production and market is highly informal, and enacting quality specifications would be unlikely to effect change in itself. However, thoughtful legislation in the future means can certainly serve as a tool to increase the success of iodization.

Unavailability of iodized salt - The most proximal and obvious barrier to poor iodine intake is highly limited access to iodized salt. The most recent statistic published indicates that only 2.4% of the salt consumed in Haiti is properly iodized (43). This is lower than figure in 2000 which estimated the consumption of iodized salt to be 11%. Imported iodized salt is typically available in larger grocery stores in places such as Port-au-Prince and Cap Haïtien. The few with adequate consumption of iodized salt are assumed to be those who reside in urban settings, be more highly educated, and have higher socioeconomic status. It is usually believed that in order for iodized salt to be sustainable, any costs involved in iodization should be included in the price of the salt (46). However, the current economics of supply and demand do not allow thisxxi. While there is the option of importing iodized salt, the government is opposed to this option because it would economically destabilize many communities that are dependent on salt production.

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increased in the US because the US Public Health Service began a national campaign to educate housewives to ask grocers for iodized salt (17).

xxi For example, the University of Notre Dame can produce a bag of double-fortified salt for around 23 cents, but they sell it at 10 cents to compete with local salt.
**Past Recommendations**

In 2006, the Network for Sustainable Elimination of Iodine Deficiency, also known as the Iodine Network, visited the country to assess the current challenges of salt iodization to eliminate IDD. Based on their findings they identified several issues such as: unclear roles for addressing IDD/USI at the governmental level; a limited awareness of IDD among partners and donors; a scarcity of current data on IDD; the lack of a national coordinating body; and a lack of support from the medical and civic society. They recommended temporary assistance that could include either complementary salt importation and/or iodine supplementation to higher-risk groups. The report cited the lack of domestically produced salt of higher quality as the greatest obstacle to USI.

To address this problem the Network suggested the adoption of modern salt pond production using serial ponds. They said that this would in turn require mapping for appropriate land, as well as investment by the government and partner organizations. Iodization was recommended to take place at the production site, along with the use of consumer packaging such as LDPE that would minimize the loss of iodine. Regarding public education, the Iodine Network believed that a campaign was needed to promote the use of iodized salt and curb the practice of household salt washing as well as promote the use of LDPE packaging.

In July 2009 salt consultant for the Micronutrient Initiative, Mohan Rallapalli, came to Haiti and also made recommendations for the country in pursuing iodization (47). Some of these included:
• the need for a central coordinating agency for IDD control
• clear delineation of roles for each involved agency
• improvement of the quality of salt produced in the country
• financial assistance to the run the country’s iodization plant

At this time it was reported that the Ministry of Population and Public Health and (MSPP) was hoping to establish the creation of an interministerial committee for salt iodization, but currently there does not appear to be one. Unfortunately there are available MSPP nutrition employees in the North East or Artibonite that would potentially be able to monitor the quality of iodized salt were it produced in these regions.

**Recent initiatives**

Currently the nutrition department in MSPP believes that IDD is increasing nationally and that iodized salt should be the solution. While a significant supply of domestically iodized salt has yet to enter Haiti’s market, efforts to begin iodizing the nation’s supply of salt began more than a decade ago. In 1998 MSPP began working on a plan to introduce iodized salt in the country (43). In 2002 a partnership was formed between the government, UNICEF, Kiwanis, and the University of Notre Dame, where the Lolita salt company would begin producing iodized salt under the Flamingo brand. However, several months later the

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**xxii** MSPP has been providing the raw salt and potassium iodate to organizations running the plants. However, it was not able to pay the operational costs as of mid-2009. This is also why stocks have been held up at the plant.
partnership came to an end with Lolita going bankrupt in 2003 in part because the purchase price for domestically produced salt could not be kept as agreed (37).

In the past UNICEF has donated three salt iodization plants to the government\textsuperscript{xxiii}. One of them was lost in 2004 during Aristide’s departure, and the other two are in working condition being managed by MSPP in a facility in Cité Militaire, a relatively insecure area close to Port-au-Prince. Besides Cité Militaire, there is no other salt iodization facility in the country. A quality control lab was meant to be installed next to the facility. Currently, however, there is a large space for the lab at the facility but there was no lab equipment present (37).

The iodization facility houses two fortification units that function as continuous spray-mixing, Glotra Type machines. The nominal fortification capacity of one unit is around 7 tons per hour. Based on daily operation the plant, the annual production would theoretically be adequate to meet the entire country’s need for iodized salt (47). However, the actual output of the facility is thought to be around 2 tons per day due to the need to air dry and sort the salt, and then to package the salt into 1 pound bags (43). The bags can be heat sealed and packaged into bundles of 25.

In 2004, MSPP authorized the University of Notre Dame to begin a pilot salt program to combat lymphatic filariasis and iodine deficiency. The current UND co-fortification operation employs around 50 people to buy local salt, clean out rocks and organic matter, manually wash it, spray it with iodine and diethylcarbamazine

\textsuperscript{xxiii} UNICEF has been involved with distributing bags of iodized salt (48), as well as distribution of iodized oil supplementation.
(to combat lymphatic filariasis), and then package it under the name Bon Sel and sold at a subsidized cost. MSPP has contracted one of the two iodization units to UND to produce double-fortified salt until 2013. Since the earthquake in January 2010, UND has been able to resume its schedule for fortification. For more information UND Haiti Program see Appendix F.

In addition to the double-fortified salt produced by UND, some exclusively iodized salt has been produced at the Cité Militaire facility, which records have indicated contain a concentration of potassium iodate between 25-30 ppm. As of 2009, 1,500 tons of salt along with potassium iodate were supplied to the facility by the government for iodization, with the hopes that the salt could be distributed to NGOs and sold as an income-generating project for women (47). In general, there has been a lack of financial resources to operate the facility and perhaps the need for a more responsive production and distribution chain.

Although the Cité Militaire facility is operable at a much higher capacity, it is still not producing iodized salt to meet the country’s need. The country has set many goals for iodization goals in the past. For example, during the period after the departure of Aristide, the interim cooperation framework resolved to provide 80% of the households with iodized salt by 2005 (50). However, it appears that many of these unmet objectives have been due more to a lack of available finances, and not government oversight.

Some research on iodization outside the Cité Militaire facility has been investigated by organizations such as the World Food Program (WFP), Micronutrient
Micronutrient Initiative and WFP-Haiti agreed to work together to produce enough iodized salt to meet 20% of the population’s need. This has led to the construction of modern demonstration ponds, along with a number of training workshops on modern salt production and iodine fortification techniques such as knapsack spraying (47). Apart from salt, UNICEF has also looked into the possibility of using bread as a distribution vector for iodine. In 2007 UND assessed the impact of having used iodized salt in Nestle’s Maggi bouillon in Miton, Haiti, as this seasoning is somewhat ubiquitous in the country.

Following tropical storm Jeanne in 2004 and the flooding of salt ponds in the Gonaïves area, Ananda Marga Universal Relief Team (AMURT) and Action Contre Faim (ACF) arrived in Haiti to focus on rehabilitation of damaged salt ponds with an emphasis on economic recovery for the producers. In 2005 AMURT assisted in the rehabilitation of 50 traditional salt ponds in Commune Anse Rouge with food for work programs. Since then AMURT’s objectives have begun to be directed towards eventual salt iodization by facilitating producers in switching to modern ponds. In 2007, AMURT began a 5-year strategic plan towards implementing both small and large-scale salt production and iodization. AMURT has constructed a larger scale salt production facility in Magasin along with a warehouse next to it (51). However, since the earthquake on Jan 12, 2010, the organization has experienced some restructuring, with more attention being shifted to relief work and environmental issues.
IV. Salt Production in Haiti (CAR)

The production of quality salt in Haiti is a crucial component for achieving successful salt iodization in the country. While some groups have called for the temporary importation of salt as a solution to combating iodine deficiency, this suggestion has been dismissed by the government because it would destabilize the economic livelihood of salt producing communities in the country. Currently it is estimated that approximately 3,000 tons of salt is imported from the Dominican Republic (37). Additionally, salt is reported to be coming into Haiti as part of school feeding programs and forms of international aid. The government has expressed a specific interest in increasing the domestic production of salt while minimizing the importation of salt.

As of now there is no systematic data collection of salt production in the country. The total population demand for salt in Haiti is estimated to be 30,000 to 45,000 tons annually based on the average individual intake of salt and the loss of salt that occurs due to washing (37). While salt is also used for things such as preserving of meats and the commercial production of ice and soap, there are no significant salt industries in Haiti, such as the production of caustic soda or soda ash (37). In 1995 a study done by MSPP, UNICEF, WHO, and PAHO stated that there were 586 producers in the country producing approximately 130,000 tons of salt per year. Salt producing departments in Haiti include the North East (Jacquezil, Caracol), North West (Baie de Henne), and Artibonite (Grande Saline, Gonaïves, Hatte Roché, Coridon, Pointe de Mangles, Bacadet, Magasin, Grand Port, Anse Rouge). Salt production typically occurs starting from September to the following
June, with the months of July and August having more rain that prevents harvesting (37, 52). Producers typically have 3-4 harvests per year.

Salt is typically harvested by female workers who do not own the ponds themselves. The salt is first harvested by hand into wicker baskets and then rinsed in a pool of ocean brine in order to remove mud and visible impurities. While the salt is noticeably cleaner after this process it still appears inadequately clean to most Haitians. After this washing, the salt is dried in large piles for a few days either outside or in thatched huts before being placed into sacks. Salt harvesters are typically paid less than 100 gourdes for one harvested sack\textsuperscript{xxv} of salt. In times of adverse market conditions where salt prices may be low, the harvesters may sometimes be paid with salt instead of cash, delaying disposable income from reaching poorer individuals in salt producing communities.

Much of the salt that is produced in the Artibonite is transported by small boats to larger towns such as Petit Goave, Jérémie, Léogâne, and also Port-au-Prince, to be purchased by wholesalers. In the Commune Anse Rouge village of Pointe de Mangles, for example, there are believed to be more than 50 boat owners who regularly carry salt shipments to the rest of the country. Salt produced in the Artibonite is also distributed to other parts of the country by trucks, with some salt going north towards Cap Haïtien. The quantity of salt produced along the Northern coast of Haiti is less and generally stays closer to the regions where it is produced.

\textsuperscript{xxv} One sack is approximately 50-70 kg.
**Traditional salt production**

Salt ponds are typically rectangular shaped and can range anywhere from 9x11 meters to 40x30 meters (44). The characteristics of salt are thought to have variability between geographies as well as individual ponds within the same producing community. For example, it is thought that salt production in ponds close to urban areas have a high level of pollution due to solid waste management problems (43). Individual ponds will also vary in quality based on factors such as the level of upkeep invested by each producer along with the characteristics of earth surrounding the pond.

Despite the individual and geographic variability in salt quality produced in Haiti, the main factor that causes the salt to be of lower quality than salt produced in other countries is the traditional method of production still being used by Haitian producers. As previously mentioned, salt produced in this method is not able to retain iodine as well, and is prone to household losses due to washing. Based on the concentration at which certain minerals precipitate from water, the precipitation of salt should not occur at a density greater than 29 degrees Beaume because a greater amount of impurities solidify in the water past this point. While the average density for traditional salt pond harvesting is not known, a spot measurement taken in 2010 from one pond ready for harvest revealed that the brine was already past our maximum hydrometer reading of 35 degrees Beaume.

Aside from a very few number of producers who have recently started experimenting with modern pond construction, the majority of salt producers in
Haiti employ the traditional single evaporation pond method to produce salt. The larger-granule salt is used throughout the country.

**Modern Salt Production**

In contrast to the traditional single evaporation pond, the modern method that is being encouraged as a replacement uses a sequential series of ponds. This allows the density of the seawater to be controlled where the precipitation of sodium chloride can be separated from the precipitation of other minerals in the seawater. The modern serial pond setup consists of three separate evaporation areas designed to maximize the proportion of sodium chloride precipitation in the final stage\(^{xxvi}\). Compared to the traditional production method, modern serial pond production requires a more active process that producers must be willing to learn and correctly apply. In essence, it requires more effort to produce salt using the modern method.

\(^{xxvi}\) The evaporative process of modern serial ponds is typically divided into three stages. These divisions are referred to as the reservoir, condenser, and crystallizer sections. The reservoir serves to concentrate the brine in the initial stages as well as allow the sedimentation of impurities in the brine. Next, the condenser allows for further concentration of the brine and the precipitation of calcium sulfate (gypsum), which also has some commercial value. The final stage occurs in the crystallizer when the sodium chloride precipitates. Brine in this stage needs to also be controlled so as to not allow the concentration to increase beyond a specific density, usually around 29 degrees Baume. If this occurs the salt will be less pure, specifically because of precipitated magnesium salts. Density of the brine through all stages can be monitored inexpensively with a hydrometer. Following harvest, the concentrated bittern must be removed from the crystallizer through piping. For more detailed information, refer to manual prepared by MI consultant Mohan Rallapalli (44).
The modern serial pond method of production is also thought to have certain economic advantages over traditional single evaporation ponds. Because the pond is designed to be shallower with more frequent harvests, the loss of a single harvest due to unexpected heavy rainfall is less catastrophic. Less work is also needed for repair following heavy weather damage.

The main advantage to salt production with the new method being introduced is the ability to produce salt faster, resulting in greater production and marketable salt. Because the method is not familiar, producers are still holding back to see if this is actually more profitable for themselves. There is also some understanding that producers may not have the financial certainty to dig up existing ponds and replace them with serial ponds, and have actually requested financial assistance to do so (37). Three estimates from for the cost of labor to convert a traditional pond to a modern pond have ranged from 200 to 600 USD.

While it costs more to construct a modern salt work on unbroken land compared to converting an existing traditional pond, the producers in Commune Anse Rouge who have begun constructing modern salt ponds were doing so on unbroken land. This is likely because it would not jeopardize the profits of the old traditional pond producing salt. So far there is one person in the North East and two

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xxvii Currently salt prices in Haiti are much lower than usual, with supply exceeding demand, and many producers storing salt in hopes that the price will increase in the future. Part of this may be due to imported salt and salt being given as aid. If the country continues to remain oversupplied with salt, the new method of producing salt may increase the supply and further decrease the market price. Effort should be taken to avoid this outcome. See recommendations at the end of this report.

xxviii The estimate for the labor to convert a pond of 20x40m has been given to be around 600 USD (47).
in the Artibonite who have adopted a modern pond layout. It has been suggested that once 10-15 producers adopt modern serial ponds for salt production, other producers will naturally begin to follow (47). However, it is not known whether this will also catch on for pond conversions or just for newly constructed ponds.

According to the aforementioned recommendations from a previous MI consultant, the sustainability of the salt iodization program in Haiti “depends entirely on improving the quality of salt produced within the country.” Additionally, the Iodine Network’s findings determined that the domestic salt of inadequate quality was the “single greatest obstacle to USI.” Salt fortification programs such as that run by UND have also expressed a need to establish a consistent supply of high quality salt in order for their operations to continue running, and would chose to have this be from a domestic source if at all possible (53).

During a workshop held in September 2006 (43), MSPP along with other private and public representatives agreed on 3 resolutions: developing activities for local salt iodization; improving the quality of domestic salt; and cooperation in assisting technology transfer. Based on these priorities, it will be important to understand the current barriers to adoption of modern serial ponds. The task of assisting small-scale salt producers comes with many challenges (54). Some of these include: limited markets for their product, rudimentary packaging practices and limited equipment, and particular vulnerability to weather. Additionally, their investment decisions are directly tied to their ability to improve their families’ lives

xxix These sources include two reports and a conversation with a local salt technician (52,47).
and stay in business. In Haiti almost the entire domestic supply of salt comes from small-scale producers.

**Organizational initiatives with the salt producers**

In 2006 WFP and MI had set a goal to ensure production of 20% of the population demand for iodized salt, or roughly 8000 metric tons (52). Because virtually all of the salt produced in Haiti is not good enough to be iodized, attention was focused on assisting producers in adopting a better salt production method. Consequently, modern demonstration salt ponds were built in both the North East and Artibonite Department. With the help of Micronutrient Initiative which provided salt consultants, modern salt production facilities were constructed in Magasin, Jacquezil, and Caracol, and Fosse (the last three are in the North East Department). See appendix G for more details. Additionally, the World Food Program has technical assistants working with producers in the North East Department. In parts of the Artibonite, the Ministry of Agriculture is doing similar work.

In 2006-20007 MI consultant Mohan Rallapalli held training sessions for a total of 47 producers in the villages of Jacquezil in the North East, and Pointe de Mangles in the Artibonite, on the process of modern serial pond construction and salt production using the new technique. Hydrometers and instruction manuals created by Mr Rallapalli were available to participants. A repeat trip to Caracol (close to Jacquezil) in 2009 reviewed the techniques demonstrated from the first trip. Instruction on how to use backpack sprayers to add 50 ppm of potassium
iodate to the salt was also given, emphasizing the need to label the bag for household sale with a message not to wash the salt.

Similar training has been given by the Association des Œuvres Privées de Santé (AOPS) in the Artibonite in 2008, who developed another training manual for producers using resources created by Mr Rallapalli.

xxx AOPS received financial assistance from Fon Asistans Ekonimik ak Sosyal (FAES) to complete their training activities with producers.
V. My Research

Background

In order for producers to adopt modern serial ponds as a replacement to their traditional ones, there are many potential issues that need to be addressed. One issue is that the technique of producing salt using modern ponds is more complex than traditional single ponds, and problems can arise in which producers do not have familiarity resolving\textsuperscript{xxx}\textsuperscript{i}. Though some communities have received training in modern production methods, it is not known whether certain producers perceive a lack of technical knowledge or assistance, and if this is a barrier that could be overcome with additional training sessions or guidance.

Another primary issue that needs to be examined deals with perceived economic costs and benefits to constructing a modern pond. Producers who have been involved in previous training sessions sponsored by MI and AMURT have been told about some of the advantages to modern serial pond production, but it is not known whether there is a lack of initial capital, or a perception of economic return that could serve as a watershed to modern pond conversion. The cost of providing financial support on acceptable terms to producers may ultimately not be large\textsuperscript{xxx}\textsuperscript{ii}. Tools required to convert a traditional salt pond into a modern one are basic and

\textsuperscript{xxx}\textsuperscript{i} These problems might include proper control of the gravitational flow of water through the system, correct monitoring of brine density, or unexpected seepage of brine between one another ponds (47).

\textsuperscript{xxx}\textsuperscript{ii} Based on calculations arrived through discussion with salt producers, the necessary financial support required to facilitate the transition to modern serial ponds for all producers in Haiti may only amount to 200,000 USD, based on giving a 30\% assistance to estimated costs (47).
expected to cost less than 100 dollars (37). However, there may be other issues needing consideration such as the acquisition of additional equipment\textsuperscript{xxxiii} or other engineering concerns.

Particularly, the perceived adequacy of their current pond size for conversion may be a concern, considering that the demonstration facilities for modern salt ponds were constructed to be larger than individual traditional ponds. While it has been suggested that modern serial ponds can be created in scaled-down dimensions to that of existing traditional ponds\textsuperscript{xxxiv}, it is not known whether producers perceive a land inadequacy, and if this is preventing them from converting their ponds (47).

Finally, it is not known whether there are other perceived advantages or disadvantages to salt production using modern serial ponds, and how this factors into choosing to convert traditional ponds. It is believed that the salt produced from modern ponds is purer, but how does this affect the decision to convert? Also, some producers have been told about the importance of iodine and need for salt iodization, but likewise it is not known how this shifts the balance of economic decisions.

\textsuperscript{xxxiii} Regarding salt production, the salt producers may also need assistance for other things such as pumps, weighing machines, and hydrometers, etc.

\textsuperscript{xxxiv} When modern serial ponds are created on smaller plots, it has been proposed that the reservoir ponds should not need to be included in the layout. Rather the pond should include only condenser and cyrstallizer sections.
**Purpose of the Study**

The purpose of my research was to further investigate the barriers to producers converting their traditional single evaporation ponds into modern serial evaporation ponds. This has repeatedly been discussed to be the single greatest obstacle to achieving USI for the country. In order for the new salt producing technique to be successfully adopted by producers, there are many perceived hurdles on the part of involved NGOs and government representatives, such as: appropriate education and training on pond construction; perceived economic benefits of the new technique; economic capital to convert existing ponds; perceived adequacy of land area to employ the new technique; and knowledge of salt iodization.

Additionally, because of the limited availability of salt produced using the modern serial pond technique, there has been little examination to the perception of such salt, and whether its quality would be desirable to producers. The strategy of crushing salt has been used to prevent the practice of household salt washing. It is not known whether such a strategy might work in Haiti.

**Methods**

Based on available literature review as well as conversations with AMURT, UNICEF, WFP, and MI representatives, we developed a 20-question survey directed towards understanding the salt producers’ perspective of adopting modern
production methods\textsuperscript{xxxv}. The survey was designed to address 4 specific issues: current struggles with salt production, factors preventing adoption of new method, knowledge of iodine and iodization, and perception of iodization options. In order to establish key objectives, the survey was developed through an iterative process with critical input and perspective obtained from Amber Munger of Article 29 Organization. Significant contributions were also given from Magalie Personna at UNICEF. The survey was designed to last between 15 to 30 minutes. See Appendix H for the English version of the survey. After the survey was appropriately tuned to address specific concerns, the survey was translated into Creole and examined for cultural sensitivity by a professional Haitian translator living in Port-au-Prince.

Salt producers in the northwest region of the Artibonite department\textsuperscript{xxxvi} were recruited for participation based on contact with the community of local salt producers through a local Ministry of Agriculture representative and AMURT. Logistical needs were provided by Amber Munger and AMURT organizer Demeter Russafov. A French/Creole translator was hired from the community of La Sources Chaudes to participate in all of the interviews. Salt producers who participated in the survey were reimbursed with snack foods (valued under 1 USD) after the conclusion of the interview. Based on our available time, we were able to pilot the

\textsuperscript{xxxv} See appendix I for English version of the survey.

\textsuperscript{xxxvi} Originally the survey was to be administered in regions where AMURT, WFP, and MI have been active in working with producers. This was to include two geographic salt producing regions, the northwest part of the Artibonite department (Commune Anse Rouge), and the salt producing villages in the North East Department including Caracol, Jacquezil, and Fosse. However, due to the January 12 earthquake, the study did not include communities in the North East. In May 2010 another trip was taken to the Artibonite department to talk with more salt producers in the region.
questionnaire on 2 individuals and then conduct 34 interviews with salt producers in the villages of Magasin, Grande Carrenage, and Pointe de Manglesxxxvii.

Results

Participants included 34 respondents from the villages of Magasin (17), Grande Carrenage (7), and Pointe de Mangles (10) which consisted of 31 males and 3 females. The median age of the group was 41 years, ranging from 23 to 78. Almost all participants described income-generating activities besides salt production involving agriculture, livestock, and fishing, depending on which activities were characteristic for each village. Salt prices at the time were generally acknowledged to be lower than usual. Consequently, many producers were storing their salt in thatched huts next to their ponds in order to be sold when prices increase.

The production of salt per pond each season varied from 60 to 3600 sacksxxxviii per harvest with a median of 140, and an inter-quartile range of 100 to 240 sacks per harvest (assuming the average of three harvests per season). However, in Pointe de Mangles several participants stated that they had either one or more ponds that had not been producing any salt for the past several years.

xxxvii In the villages of Magasin and Grande Carrenage, interviews took place in January 2010. Participants from Pointe de Mangles were interviewed on a return trip in May 2010.

xxxviii A sack is estimated to contain 50-70 kg of salt. In some areas salt producers sell salt in units of bariks, which consists of a certain number of sacks. However, as previously mentioned, the number of sacks is not the same for all places. For example, a barik consisted of two sacks in Pointe de Mangles, and twelve sacks in Magasin and Grand Carrenage.
Overall, the median price each sack had been recently selling for was 54 Haitian dollars\(^{xxxix}\) (range 25-83).

Although not directly asked to each participant, it was common for producers to spend in the range of several hundreds to a few thousand US dollars each year to clean the mud out their ponds due to flooding and also maintenance between harvest seasons. The frequency of cleaning varied between participants, and it was hard to determine typical annual expenditures due to inconsistent weather damages and varying levels of maintenance cleaning. Apart from pond cleaning to remove mud that regularly filled their ponds, the only expenditures in improving salt production mentioned were three individuals who purchased pumps to bring seawater into their ponds, and one participant who purchased PVC pipe to facilitate the same purpose.

\textit{Knowledge of Modern Pond Construction}

When asked about their level of knowledge for employing modern pond techniques, 47\% of participants felt like they had enough training to do so (59\% in Magasin, 29\% in Grande Carrenage, and 40\% in Pointe de Mangles). All of the participants from Magasin and Grande Carrenage who had attended a prior workshop on salt production felt like they had sufficient training, and vice versa. In Pointe de Mangles, there was one individual who had attended a prior salt production workshop who did not feel like she had enough knowledge to employ modern salt production techniques. Additionally, three participants from Magasin, zero from Grande Carrenage, and two from Pointe de Mangles stated that although

\(^{xxxix}\) Currently, one US dollar is approximately worth 8 Haitian dollars.
they did not have enough knowledge to employ the modern salt production techniques themselves, they knew someone who did. Altogether, 21% of survey participants felt that they did not have enough knowledge and also did not know someone who had enough knowledge to construct a modern salt work.

Barriers to Converting Ponds

88% of the participants stated that they were interested in the adopting the new salt production methods. While not directly asked to state why they were interested in converting, many (44%) brought up comments suggesting they believed the modern production would be economically advantageous\(^x\)\(^i\). It is believed that this number would be have been higher had participants been specifically asked about a financial advantage to the modern production method. Reasons given by the other participants for not being interested were that they do not have the financial or technical ability to convert their pond, or adequate knowledge about the benefits of the new production method.

When asked about the biggest challenges to converting to the new production method, the most identified problem was the financial capital required to convert the pond\(^x\(^ii\)\) (56%), followed by the belief that they did not have enough land to create a modern pond (21%). Out of these 7 individuals stating that they did not

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\(^x\) Participants who stated that they were interested in the modern pond technique because it was important to produce cleaner salt were included in those giving a response suggesting an economic advantage to the salt. This is based on a portion of the survey where almost every participant indicated that a cleaner sample of salt was said to have a commercial advantage in price and salability over a less clean sample.
think they had enough land, the number of ponds owned by each was 1,2,3,3,4,5 and 10\textsuperscript{xlii}. Two of the participants from Magasin, three from Grande Carrenage, and two from Pointe de Mangles did not know enough about the modern method to give a valid response.

**Salt Quality**

Participants were shown unlabeled side-by-side samples of salt produced by both modern and traditional methods. They were asked to decide if there was a difference in commercial desirability between the two salts. In both Magasin and Pointe de Mangles, participants almost unanimously agreed that the salt produced using the modern production method would be preferable to sell, in terms of both ability find a buyer and economic profitability. The typical estimate given was the modern salt could be sold for 50 percent additional cost (for example, 600 Haitian dollars for 12 sacks for the modern salt, versus 400 Haitian dollars for 12 sacks of the traditional salt). Participants stated that the salt produced using the modern serial pond method was cleaner which gave it commercial desirability.

Interestingly, over subsequent days of testing in Magasin, both samples became crushed from repeated handling, particularly the sample of traditional salt. Consequently, prior to testing in Grande Carrenage the traditional salt sample was replaced with a new unhandled sample of traditional salt, while the modern salt

\textsuperscript{xli} This figure includes 17% of the participants that stated the issue was regarding shifting the ground into the new formation required by the modern method, which is fundamentally a financial issue.

\textsuperscript{xlii} All participants were also asked whether additional ponds or land was adjacent to other ponds. Of note, seven participants were confined to the size of a single pond,
sample was continued for testing because it had not been crumbled to the same
degree. Using these two samples of salt in Grande Carrenage, it was surprising to
find that now participants believed that the sample of traditional salt was now
considered easier to sell because it was identified as more beautiful and having
larger granules. Participants now stated that the traditional salt sample was worth
50% more than the modern salt\textsuperscript{xliii}. Not only were the relative cost differences
between the two samples maintained, but the absolute prices quoted for each had
been reversed to where the second sample of traditional of salt used in Grande
Carrenage was said to be worth more than the first sample of modern salt shown in
Magasin.

\textit{Knowledge of Iodine Deficiency and Iodization}

Part of our questionnaire was developed in order to gauge the understanding
of salt iodization and iodine deficiency diseases. Unfortunately it was difficult to
accurately gauge this knowledge in Magasin and Grande Carrenage because of
poorly controlled information sessions that were held prior to giving the
questionnaire\textsuperscript{xliv}. In Pointe de Mangles, eight out of 10 said that they knew of
disorders related to inadequate iodine intake. However, only five could identify an
actual resulting health disorder (goiter was the only correct disorder mentioned).

\textsuperscript{xliii} Price quotes for the salt samples were not part of our initial questionnaire but
were taken informally with several of the participants from both locations
\textsuperscript{xliv} When asked specifically about the importance of iodine in the diet, many
participants were able to state that deficiency would lead to goiter, and that it was
important for health in children. However, in many cases this knowledge was
believed to have come from pre-interview introductory sessions, as well as
One individual thought that inadequate iodine intake could result in hypertension, and another thought it resulted in hypertension and heartburn.

When asked about their interest in having their salt iodized in the future, almost all participants expressed interest in having their salt iodized. The most commonly cited reasons were that it was thought that it would give their salt an economic advantage, and that the iodine would have beneficial health effects. However, several participants were unclear about how iodine could be added to the salt. Some believed that the salt produced with modern ponds would already contain iodine, and others asked if the iodine would be added directly into their pond water. In general, the knowledge of salt iodization requirements and methods was very poor among participants.

Additional information about iodization was gathered from several participants outside the structure of the original survey. Although not asked as part of the original survey, there was a natural preference stated by almost all participants for localized iodization over iodization done in Port-au-Prince due to the belief that the former would be more profitable for them\textsuperscript{xlv}.

\textsuperscript{xlv} Initially the question included in the survey was an open-ended question about the best way to iodize salt. The question was intended to examine the perceived advantages and disadvantages between iodization methods such as backpack spraying, drip-feed systems, or mechanical sprayers. Although some of the participants had taken part in training workshops recently held in Magasin, none of the participants could not demonstrate comparative knowledge of these options. In Grande Carrenage the question was replaced with one on the preference for

unplanned explanations offered by the translator before the individual survey questions were completed.
Study Limitations

Because of unexpected events following the January 12 earthquake and logistical limitations, this study did not include feedback from salt producers along the northern coast of the country. Although the questionnaire was developed with input from various stakeholders, there was still a lack of resolution in the questions for some of the intended topics. For example, with those who showed concern about the amount of land required to convert to a modern pond, it is not known how much land they feel is necessary, or specifically what issues could be addressed to change this.

It was found that almost everyone who attended a workshop on salt production felt like they had enough knowledge to implement the modern production method. While confidence in that knowledge was used as a proxy, it is possible that individuals may have overestimated their competency because the question did not directly ask the participant to provide evidence of knowledge. Additionally, our study did not look individually at the perceived knowledge of modern salt pond construction versus modern salt production.

Some other limitations to the study came from delivering premature education of iodine to participants. A lot of information gathered from participants, specifically knowledge from participants in Magasin and Grande Carrenage about the effects of iodine on health, was excluded from our results because of conversations directly prior to conducting the interview. Also, our translator took iodization within the commune versus nationally centralized iodization was substituted for the original.
the liberty to add additional explanations he felt were necessary that subsequently appeared in the responses given back to us during the interview\textsuperscript{xlvii}.

\textsuperscript{xlvii} For example, at the beginning of one field day producers were told by the translator that iodine is added to the salt to kill microbes in the salt. Subsequently all of the participants that day expressed awareness that their salt needed to have iodine to kill the microbes in it.
VI. Additional Observations and Discussion

Traditional salt production observations

Based on visits to the traditional salt ponds in Commune Anse Rouge that were accompanied by a renowned salt expert, several observations were made about the effectiveness of salt production currently being used by local producers. Because the bittern after harvests is not being drained from the pond, magnesium has built up in the ponds and in the earth surrounding the ponds. Not only does this impart the salt with the qualities previously discussed to be detrimental to iodization, but the high magnesium buildup in the pond water can also decrease the overall production rates of salt. Additionally, because the earth immediately surrounding the pond is often piled up very high, the flow of wind directly over the pond is weakened, which can also decrease production levels.

Salt quality

As previously discussed, the problem of poor salt quality is a huge barrier to iodization. Currently salt that is being fortified at the facility in Cité Militaire is also washed there. Because of the poor initial quality of the salt being used, domestic salt is typically washed 3 times at the facility, with washing said to result in the loss of up to 25 percent of the original quantity of salt. This adds a significant markup to the cost of the final product. However, with certain washing procedures that use brine for washing and filters that allow for repeated uses of the brine, losses due to washing could be kept to under 5 percent\textsuperscript{xlvii}.

\textsuperscript{xlvii} based on the experience of a salt expert working in Haiti.
In order to dissuade consumers from washing their salt, the alternative of having the salt crushed has been successfully used places such as in Gujarat, India (37). It is not known whether such a strategy would work in Haiti. However, informal assessments with local women\textsuperscript{xlviii} suggest that some would still opt to wash a given sample of crushed traditional salt before using it. One woman gave a demonstration of how a small amount of water could still be applied to the crushed salt. This ‘washing’ increased the perceived cleanliness of the salt, and did not entirely dissolve the sample. It is not known whether the salt could have been crushed more finely by a mechanical process, as nothing like this was available at the time. Unfortunately, the option of salt crushing was not fully examined in this study, and its ability to prevent washing is generally uncertain. The sample of crushed salt is shown in appendix I.

An interesting revelation in our study came by accident when we found that participants believed a sample of traditional salt was preferable to a sample of modern salt due to the larger grain size of that particular sample (as describe in the previous section). In the salt we observed from producers, in almost every case the modern salt appeared visibly cleaner, with no situation where the traditional salt surpassed the color or purity of the modern salt. With granule size there was some variation between ponds, an outcome determined by the depth of water evaporated before a given harvest. A previous study had identified that the most important characteristic for consumers purchasing the salt is its color (37). While our experience does not necessarily dispute this, our survey found that the size of salt granules could also play a deciding role in desirability. Haitians generally prefer

\textsuperscript{xlviii} in the village of La Sources Chaudes.
domestic salt that has larger grains compared to domestic salt with smaller grains\textsuperscript{xlix}. Our comparison of salt suggested that the salt produced by the modern serial pond method might not always appear more desirable than traditionally produced salt. If the traditional salt produced with the single evaporation pond has larger sized crystals and lacks visible bits of mud, consumers may prefer it. As one might expect, this might prove to be a disadvantage to crushing traditional salt as an attempt to prevent washing.

Increasing the adoption of modern salt production could bypass the need to invest in extensive filtering or crushing processes. However, even with the cleaner modern salt there may still be some washing. Without consumer awareness some may continue to wash their salt out of habit regardless of visible impurities. This consideration is one reason why consumer education is crucial to successful iodization.

**Modern Salt Adoption**

*Financial resource and support*

Salt producers tend to be wealthier than average in their own communities. However, based on weather and price fluctuations, the transition to modern ponds is still seen as a large risk. Even if there were no qualitative improvement in the salt, in Commune Anse Rouge it is generally still believed that modern ponds are

\textsuperscript{xlix} It should be noted that although Haitians prefer larger crystals over small crystals in the domestic salt they purchase, what is still more preferable than large grained domestic salt is commercially imported salt purchased at the store, because it is cleaner and does not have to be washed. The reason large crystals are preferred in domestic salt is because the amount lost to washing is less for larger crystals.
economically advantageous, both in regards to upkeep costs as well as increased salt production. Because of this, it appears that the eventual conversion of ponds will take place given more time and more training sessions. However, some suggestions have been given to speed up the transition process. MARNDR representative Pascal Adisson believes that establishing a credit program would allow producers to obtain loans to finance pond transitions. Alternatively, MI consultant Mohan Rallapalli calculated that subsidy terms agreeable to producers could potentially amount to only around 200,000 USD total (47).

**Perception of required land**

One of the limitations expressed by some producers to adopting the new system is having enough area to construct the modern system. Part of this may be due to the construction of the larger demonstration facility in Magasin (see Appendix G), which is also close to the other 2 villages where survey participants were recruited. A local salt technician said that he believes a minimum of roughly 1/8th of a *kawo*¹, or around 1600 square meters, would be needed to support salt production with the modern production setup. Similar to this, MI consultant Mohan Rallapalli says that modern salt ponds can be constructed at small dimensions, that there are salt manufacturers in India with modern ponds covering only 1000 square meters. Review of existing ponds in Haiti suggests that there are several ponds that are smaller than these sizes. However, what was of note in our survey was that those who believed they did not have adequate land were not necessarily the ones with less available land. Also, while approximately 20 percent of participants
believed they had an insufficient amount of land, this number may have been higher if participants had been directly questioned. Given some confusion that may have arisen from previous interventions\textsuperscript{\textasteriskcentered}, it seems that clarification on land requirements, along with specific demonstration of small-scale feasibility\textsuperscript{\textasteriskcentered} may be particularly encouraging to producers in Commune Anse Rouge.

In the North East department many of the challenges facing producers to adopt modern ponds appear similar to those seen in the Artibonite (Commune Anse Rouge). Reportedly, some potential barriers in the region include: difficulty in establishing a community salt work, potential expectation of project support to initiate assistance, and inexperience with modern salt production combined with insufficient technical support. One challenge unique to the North East has been the report that producers are concerned that the modern salt production is too vulnerable to rain (52). There, the demonstration ponds have experienced poor production due to storm damages and environmental challenges, and it is possible that this poor production was attributed as a flaw in the modern pond design instead of simply the problems themselves.

\textit{Level of training}

Interest in the modern salt production method has been growing in salt producing villages in Commune Anse Rouge. One representative for the Ministry of

\textsuperscript{\textasteriskcentered} based on the French \textit{carreau}, approximately equal to 1.29 hectares or 12,900 m\textsuperscript{2}. This unit has been traditionally used in Haiti for measuring land.

\textsuperscript{\textasteriskcentered} Initially, it was hoped that it might be possible to build a large communally owned salt work based on each producer forfeiting the ownership of his individual pond(s) to have the requisite land. However, this has not occurred due to the challenge of forfeiting individual ownership in exchange for group ownership.
Agriculture working closely with these producers believes that the producers are now more interested in learning about the newer salt technology, but that more training courses are needed. It is possible that the demonstration facilities being in Magasin have led to salt producers in that community having a greater awareness of modern pond techniques. Though not statistically significant, the level of knowledge may be lower in Grande Carrenage, the village right next to Magasin. This suggests that future training classes need to focus more on outreach into neighboring villages in order for wider-scale adoption to be possible.

As mentioned previously, a few organizations have already been involved in educating salt producers on modern salt layout and production. These include workshops sponsored by MI (Micronutrient Initiative) consultants and AOPS (Association des Œuvres Privées de Santé). Based on the feedback from our survey, the overall impact of these training sessions appears to be significant. Almost 80 percent felt like they had either the knowledge themselves or access to someone with the skills to employ the modern production methods. Additionally, in 2009 MI consultants also held workshops on salt iodization through backpack spraying. While it was difficult to determine precisely, it appears that knowledge of iodine and iodization is not at the same level with local producers. However because there is not an immediate plan to begin spray iodization, the consequence of inadequate iodization knowledge seems less significant at this point.

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\[iii\] This could demonstrate key variations for smaller ponds such as the width of bunds and the option to omit the reservoir. 
\[liii\] based on personal communication in April 2010.
**Additional training courses**

While many producers stated that they were not lacking knowledge for implementing modern salt production, the sponsorship of additional training courses would provide an opportunity to advertise the benefits of modern ponds. This would include both the potential economic and health benefits. Additionally, the cost of doing so could be kept to a minimum. In doing so, suggested the course duration of 5 days and requested assistance of 1 USD per day per participant for food along with money to print production manuals. Currently the only available Beaume meters are those that were previously brought to Haiti by Mohan Rallapalli, which would not be expensive to provide.

**Potential role of consumer subsidies and additional iodization sites**

Currently the distribution of salt from production areas to the rest of the country is a very decentralized process, where producers communicate with purchasers throughout the country and deliver salt directly to them. With all of these unique distribution routes, having only one location for iodization will always be inconvenient for a significant number of producers wanting to iodize their salt. Currently, the small amount of salt that is fortified at the Cité Militaire facility needs cost subsidies to compete with unfortified salt. Because of the increased costs of requiring all salt to be transported to a single iodization facility before being transported to purchasing destinations, greater cost subsidies and/or additional iodization sites may be needed if iodized salt production scales up in the future. In Magasin, for example, there is already a constructed warehouse facility that could be suitable for iodization, with some training already given on iodization.
**Too much salt?**

Issues regarding supply and demand levels lead to complex considerations for a country the size of Haiti, and are not discussed at length in this report. Suffice it to say that even now, as the price of salt for producers has been low for the first half of 2010, there are questions about how the influx of salt from outside the country may be contributing to the problem. Many producers now have supplies of salt building up in their storage at the same time the country has salt donations arriving for earthquake relief victims. While the adoption of modern salt production is crucial for producing sustainable iodized salt, it is important to realize that if Haiti has an excess supply of salt, the price of salt will decrease.

Because modern salt production may lead to greater salt yields in the country, some may be tempted to see it as potentially hurting the incomes of rural salt producing communities. However, such an argument is frequently made for many aspects of development in countries like Haiti, leaving it perpetually dependent on other nations to provide many of its needs. Instead, salt producers would be doing better right now if organizations were not bringing salt donations or importations into the country, but prioritizing assistance by delivering salt or iodized salt using a domestic salt source. While it is true that there are some economic uncertainties that may arise in the future from adopting modern production methods, cutting back salt imports is something that would improve the economic struggles of many communities right now.
VII. Recommendations

As discussed, one of the main obstacles to reducing iodine deficiency disorders in Haiti lies in improving the quality of domestically produced salt. Based on the work and experience of previous organizations, it is assumed that the only lasting solution to providing the country with iodized salt is through universal salt iodization using domestically produced salt, with the approval and partnership of the national government.

The work done by MI/WFP, MARNDR, and many other organizations has recently made much progress with salt producers. This work is consistent with the recommendations set out by the Iodine Network and related to the course of progress seen in other countries facing similar challenges. While the work and information gathered within this report are dedicated to the final goal of reducing IDD in Haiti by producing domestically iodized salt, this report does not attempt to provide a comprehensive strategy for producing and distributing iodized salt. Many resources that provide better overviews have already been published by the international health community. This report focuses on the remaining challenges surrounding the domestic production of higher quality salt, and provides some considerations to future scale-up of iodization. With these things in mind, the following represent a summary of recommendations arrived at through the information presented in this report:
Salt washing

Because the quality of domestic salt is currently very poor, investment in salt washing with appropriate brine and brine filters may increase the percentage of domestic salt considered usable. Following this investment the unit cost for iodizing salt would decrease, and eventually could help decrease the flow of foreign salt into the country.

Iodine Education

The importance of consumer education on the importance of iodine has been unanimously stressed, and should ideally occur in a situation where iodized salt were also available. With salt producers, this understanding could encourage pond conversion as well as enthusiasm for future participation in iodization activities. Information and teachings could be folded into future training workshops.

Resources for modern pond conversion

Based on our study results, the impact of the training workshops and investment by MI, WFP, and AOPS can be seen in the producers in each of the three study villages. In order to accelerate the transition to modern ponds, investment should be made for additional educational workshops. These workshops should be used to dispel the existing misunderstandings of modern salt production, increase the understanding of iodine and iodization, and instill confidence in applying techniques to their ponds. As of now, resources such as additional training manuals and hydrometers are said to be needed.
Additionally, as it is already being considered by MI consultants, the construction of an active small-scale demonstration pond in the Artibonite could be incredibly persuasive to producers. This should be in the form in assisting a pond owner in converting an existing smaller traditional pond, which has several advantages over constructing a demonstration pond from unbroken land.

Especially now, because of the low market price of salt for producers this year, some form of financial assistance to producers seeking to convert their ponds should be considered. As Mr Rallapalli has previously suggested, the cost of direct assistance may be feasible. Establishing a credit program for producers has been suggested by the local Ministry of Agriculture representative in Commune Anse Rouge. The organization Fonkoze, which already has several branches in the North along with representatives working in Commune Anse Rouge, might be included in such a program.

*Expanding presence to other salt producing villages*

Potential outreach to other salt producing communities such as Grande Saline should be considered. Organizational involvement here is not well known but is assumed to be sparse at best.

*Salt distribution throughout the country*

Because of the decentralized method in which salt travels from production areas to the rest of the country, the role of cost subsidies would need to continue if iodized salt were to be cost-competitive with non-iodized salt. This is partly due to
the increased transportation costs of having only one iodization facility. Additional iodization sites may decrease the amount needed level for future subsidies.

*Restricting salt imports*

As previously mentioned, because Haiti is not currently able to export any of its salt, salt imports can create an excess supply of salt which hurts the income of producers by artificially decreasing costs. Prior to the decrease in salt prices in the country, salt producers already felt that converting their salt pond to the modern production method was too great of an economic burden. It is possible that the effect of imported salt is could be hurting the income of these producers and otherwise delaying the process of adopting the recommended production methods.
VIII. Conclusion

While the public health issue of iodine deficiency seems distant to the matter of economic challenges facing salt producers, it is agreed that the most sustainable way to reduce iodine deficiency disorders involves adopting a new salt production method. I hope that the perspectives offered in this report are amenable to both MSPP and engaging organizations, as well as the producers who have livelihoods at stake. It is important to continue working towards a lasting solution. As stated previously, the estimate of 29,000 Haitian children born annually with the effects of iodine deficiency is cause for sustained efforts and commitment.
Appendix A

Recommended iodine intake

According to the US Institute of Medicine, the Recommended Dietary Allowances (RDAs) and Adequate Intakes (AIs) for iodine range from 90 µg/day for children 1-8 years old to 290 µg/day for lactating mothers. While the accepted tolerable upper intake levels (UL) of iodine for normal adults is greater than 1mg/day, children 4-8 years old have a lower UL of 300 µg/day, with children 1-3 years old having a UL of only a 200 µg/day (55).

Slightly different from the reference levels established by the US Institute of Medicine, organizations such as UNICEF, WHO, and ICCIDD have created Recommended Nutrition Intake (RNI) guidelines (56).

<table>
<thead>
<tr>
<th>Daily iodine consumption guidelines</th>
<th>according to institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Institute of Medicine Dietary Reference Intake (DRI)</td>
<td>UNICEF, WHO, ICCIDD Recommended Nutrition Intake (RNI)</td>
</tr>
<tr>
<td>0-6 mo</td>
<td>110 µg</td>
</tr>
<tr>
<td>7-12 mo</td>
<td>130 µg</td>
</tr>
<tr>
<td>1-8 y</td>
<td>90 µg</td>
</tr>
<tr>
<td>9-13 y</td>
<td>120 µg</td>
</tr>
<tr>
<td>≥ 14 y</td>
<td>150 µg</td>
</tr>
<tr>
<td>pregnancy</td>
<td>220 µg</td>
</tr>
<tr>
<td>lactation</td>
<td>290 µg</td>
</tr>
</tbody>
</table>

Source: (55),(56)
Appendix B

Iodine deficiency in newborns and infants

The most critical period for receiving adequate iodine intake is from the second trimester of pregnancy to the age of 3 years (57). The fetus is not able to produce any of its own thyroid hormone during the first half of gestation. At the same time, the fetus needs a concentration of thyroid hormone greater than the baseline levels found in adults for proper development. A natural surge in maternal thyroid hormone levels during the first trimester ensures that the fetus has adequate levels once brain development begins. Because the mother’s plasma volume is increasing at this time due to pregnancy, maternal thyroid hormone must actually double in order to provide the fetus with appropriate hormone levels. Consequently, the required iodine intake of a pregnant woman also needs to approximately double during early pregnancy for the sake of her fetus’s health (6).

In newborn infants the thyroid can only hold enough iodine needed for 24 hours before requiring additional iodine from dietary intake (16,58). Consequently, infants who experience just a temporary drop in thyroid hormone levels have been shown to have an increased risk of suffering from cerebral palsy and reduced mental-development scores, as measured with the Bayley Scales of Infant Development and the Stanford-Binet Intelligence Scales for Children (59).

Benefits to treating iodine deficiency in infants and fetuses are sometimes compared to those for reducing the number of low birth weight infants: both improve infant mortality as well cognitive development outcomes. One study found a 40 percent reduction in low birth weight infants could be seen with the introduction of iodized salt and/or iodine capsules (60). In addition to its effects on physical and cognitive development in infants and fetuses, trials have shown that providing iodine to severely deficient populations can significantly reduce child and infant mortality (61,62).
Appendix C

Measuring iodine deficiency & laboratory quality control initiatives

There are several methods for assessing iodine deficiency among humans. Some of these include goiter palpation, ultrasonography, various serological concentrations (eg, thyroid stimulating hormone, thyroglobulin, T3, and T4), and urinary iodine. Measuring serum thyroglobulin and TSH levels are newer indicators of thyroid function. Ultrasound measurement of thyroid size is less useful as monitoring method after salt iodization is implemented. Generally size measurement of the thyroid is more useful in baseline measurement of the severity of IDD. These methods may also be limited by greater cost.

Currently the standard reference for assessment is measuring urinary iodine content. Urinary iodine is the recommended method for monitoring the magnitude of the problem of IDD as well as the impact of intervention because it is able to reflect the current levels of iodine intake. Calculating urinary iodine in relation to creatinine was done in the past. However, this was not a reliable in settings such as decreased protein intake, and additionally requires added expense and burden. Spot urinary iodine concentrations are preferred for population measurements (20).

The proper measurement of urinary iodine can be challenging, and in the past laboratories had experienced problems with unrecognized iodine contamination. In order to ensure external quality control over this problem, the International Resource Laboratories (IRLI) network was established. This network was established by the CDC, WHO, UNICEF, ICCIDD, and MI to identify laboratories to serve as effective resources for their geographic regions. In the Americas region the IRLI network has 2 countries with laboratory resources, Guatemala and Peru, both of which have previously measured samples for Haiti (63). The IRLI network works with the EQUIP program run by the CDC. EQUIP is a standardization program which provides urinary iodine laboratories with an assessment of their analytic performance.
Appendix D

Target urinary iodine concentrations and iodized salt consumption for the population

Universal salt iodization, or USI, is the preferred method set by the WHO, UNICEF, and the international community for eliminating IDD. However, the goal of absolute coverage of iodized salt to the population offers an unrealistic marker for successful implementation. Realistic benchmarks for iodization provide a more realistic goal for success in reducing IDD. Some of these goals include:
- the percent of salt intended for human consumption to be iodized should be greater than 95 percent.
- the percentage of households using adequately iodized salt (between 15ppm and 40ppm) should be more than 90 percent (20).
- Iodine content should be evaluated using titration.

Additionally, goals in population urinary iodine concentration have also been set specifically to help measure effective intervention. These include:
- the median urinary iodine concentration should be between 100-199 µg/L for the general population, and between 150-249 µg/L for pregnant women (20).
- the percentage of the population with urinary iodine concentration below 100 µg/L should be below 50 percent, and those with below 50 µg/L should be less than 20 percent (64).
- monitoring population data at the regional or national level should be performed at least every five years.
Appendix E

Measuring and monitoring iodine levels in salt, WYD iodine checker

Fortified salt iodine levels can be measured using different methods such as iodometric titration, or potentiometry. Rapid test kids can be used to detect the presence of iodine in salt but perform poorly as quantitative indicators of iodine (65). Iodometric titration is accepted as the reference method for measuring salt iodine levels. It requires some basic laboratory equipment, reagents, and training to properly conduct. In monitoring the quality of salt iodization, the most important step is at the level of production and importation (20). This level of monitoring is significant for both internal and external monitoring by salt producers and government food inspectors, respectively. Titration should be used for quality control on a daily basis. Producers may choose to use a modified form of lot quality assurance sampling (LQAS) to monitor their salt.

Recently new instruments such as the WYD Iodine Checker have been developed that can provide more convenient salt iodine measurements in salt samples. The WYD Iodine Checker is a single-wavelength spectrophotometer that can be currently purchased for around 400 USD. The WYD can be used to quantify either iodide or iodate levels with the use of certain reagents, though the measurement of iodide requires additional safety considerations because due to the use of a bromine solution and need for a fume hood (however, it should be noted that all salt being iodized in Haiti would be expected to occur with iodate). The WYD is designed to test samples with a concentration within the range of 10-90 mg/kg, with an analytical error of less than 2 mg/kg. In a 2004 study published in the WHO Food and Nutrition Bulletin, the WYD was shown to be more precise than iodometric titration, while demonstrating high levels of accuracy and sensitivity (66). The CDC additionally concluded that the instrument is an accurate and reliable tool for the quantitative measurement of iodine in salt.

Measuring iodine concentrations in urine requires other analytical options that are typically based on the Sandell-Kolthoff reaction (67). Many procedures for the measurement of urinary iodine have been described (68,69,70,71,72,73).
Appendix F

The University of Notre Dame Haiti Neglected Tropical Disease Program

The UND Haiti Neglected Tropical Disease (NTD) Program was started in 1999 and is dedicated to the elimination of lymphatic filariasis (LF) in the country. The program strategy to eliminate LF is based on mass drug administration (MDA) of diethylcarbamazine (DEC) added to salt. Additionally, UND also fortifies all of its salt with potassium iodate to create their double fortified product Bon Sel. The salt is tested to ensure quality. Dr Thomas Streit serves as the director of the UND Haiti Program, with Jean Marc Brissau serving as the acting director.

The UND Program has received multiple grants from the Bill and Melinda Gates Foundation totaling 9.6m USD (5.2m in 1999, 4.4m in 2006) and scheduled to run until 2011. Additionally they have raised 2.2m through private foundations and 1.2m through the CDC, also working with other organizations and MSPP to expand double-fortified salt in the country. In the past, UND has also produced salt fortified with iodine only as part of a UNICEF contract. Currently UND has a government deal to produce salt at the Cité Militaire factory until 2013. The UND Program work closely with the Haitian government to ensure program approval.

UND purchases salt from domestic producers for around 2 cents per kg. Their final product is sold from the facility at 5 gourdes per 1 pound bag. Resellers are encouraged to sell bags for 7 gourdes each in order for the final consumer price to be competitive with locally available salt, with some reported to be selling it for 10 gourdes. In the areas where they have been selling their salt there is a demand for double fortified salt because of the prevalence of LF. It should be noted that it is not the government’s intent to double-fortify the entire nation’s supply of salt. However, while the main objective of the Notre Dame Haiti Program is the eradication of lymphatic filariasis, they have also produced salt fortified with iodine only at the request of UNICEF. UND has looked into the Gonaives area as a potential site to process crude salt into their final double fortified salt (49).

UND has attempted many times in the past to secure a domestic supply of salt for its double fortified salt production but has encountered a lot of difficulty doing so. As cited by them, two main problems commonly seen with domestically produced salt are that the salt contains visible dirt particles and also that it contains a high concentration of magnesium. The high levels of magnesium give the salt a wet and almost oily quality that makes it more difficult for salt to retain the fortified ingredients. Because of these impurities, UND must spend time and money to wash the salt before use, with most of the domestic supply of salt being too poor to use. A quote of 2-3 cents could be saved in production costs for each bag of salt sold if the salt were of a high enough quality to not require washing.

UND is supporting a local company called Group SPES, a local Haitian organization that is distributing the double fortified salt.
Appendix G

Sites constructed in Haiti for demonstrating modern salt production

The following table provides data on demonstration sites constructed by an agreement between the Micronutrient Initiative and the World Food Program (52).

<table>
<thead>
<tr>
<th>village (department)</th>
<th>area (m sq)</th>
<th>production capacity (MT/yr)</th>
<th>production history (as of July 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magasin (Artibonite)</td>
<td>22,553</td>
<td>300</td>
<td>construction finished 04/2009, 4.32MT produced in 2009</td>
</tr>
<tr>
<td>Magasin (Artibonite)</td>
<td>459,096</td>
<td>8,000</td>
<td>construction finished last year, has not produced any salt</td>
</tr>
<tr>
<td>Caracol (North East)</td>
<td>6,600</td>
<td>150</td>
<td>construction finished 07/2007, pump not available in 2007, 25 kg in 2008 due to hurricanes, none</td>
</tr>
<tr>
<td>Jacquezil (North East)</td>
<td>2,250</td>
<td>52</td>
<td>construction finished 07/2007, no production due to environmental problems</td>
</tr>
<tr>
<td>Fosse (North East)</td>
<td>6,600</td>
<td>150</td>
<td>construction finished 01/2009, no production due to technical problems</td>
</tr>
</tbody>
</table>

While it was not initially in line with the objectives of MI/WFP to construct the larger Magasin facility, AMURT decided to build this facility on its own with the help of a salt expert recruited by MI/WFP (51). Projected capacity of the larger facility in Magasin has been estimated to reach 20,000 metric tons of salt, or roughly half of the country’s salt consumption. AMURT plans to establish a revolving local fund to use future revenues for investment in development programs. However, momentum with AMURT’s salt works has been somewhat stalled due to recent restructuring of project priorities as well as changes in its staff. It is believed that the larger sizes of both demonstration facilities in Magasin may have contributed to some hesitation among producers in surrounding villages to adopt modern salt construction.

Production at the site in Jacquezil has faced problems because of repeated flooding by a river that lost its bed. Future production at this site will first require canalization of the river, which has already begun through a Food For Work project between WFP and the agricultural department. The demonstration site in Fosse has struggled to produce salt because water has been seeping between bunds, which were constructed above ground. The proposed solution involves removing some of the sandy soil and reinforcing the bunds with clay. As of April 2010, the demonstration site in Magasin was producing a harvest every week.
Appendix H

Research Survey, English Version, Page 1 of 3

Participant Code: __________ Date: __________/__________/________ Time: __________

Haiti Salt Producer Survey (English version)

Survey Questions:
Instructions: Only read responses to questions when indicated.

1. Do you own a salt basin?
   1- yes
   2- no
   98- I don’t know
   99- refuse to answer

If participant does not respond YES, do not continue the survey.

2. How old are you?
   1- 18-24
   2- 25-34
   3- 35-44
   4- 45-54
   5- 55-64
   6- 65 and older

3. What is your gender?
   1- male
   2- female

4. Do you earn income in any way besides producing salt?
   1- yes
   2- no
   98- I don’t know
   99- refuse to answer

If participant responds YES, ask 4a:
   4a. Last year, did more than half of your income come from salt production?

5. Which of the following best describes the way you produce salt?
   1- single evaporation pool
   2- crystallizer
   3- other ________
   98- don’t know
   99- refuse to answer

6. What are the biggest challenges to producing salt with multiple basins?
7. Have you changed anything in the last two seasons in your salt producing operations, and if so, what?

*If Participant responds YES, ask 7a:*

7a. If changes were made, what did they cost?

8. Considering the things just mentioned, do you feel like you have enough training to properly implement multiple basins?

   1. Yes
   2. No, but I know of someone who can do this.
   3. No
   4. I don’t know
   5. Refuse to answer

9. If you have not already, are you interested in applying the new salt producing technologies to yourself? Why or why not?

10. How many basins do you have? If you have more than one basin, are they next to one another?

11. Do you have any additional land available for salt production that is next to your basins?

12. How many bariks do you produce per basin in a season?

13. How much could you sell this amount of salt for, per barik?

14. Have you ever attended a workshop on salt production?

*If Participant responds YES, ask 14a:*

14a. If so, what did they teach you?
APPENDIX H – continued

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Participant Code: Date:    Time:

Ask the participant to examine the two samples on the table
15. Is there a difference between the two types of salt, regarding to sell more easily?
   Please explain.

15a. Is there a price difference for the two types of salt? Please explain

16. Have you heard of iodine deficiency diseases?

If participant responds YES, ask 16a:

16a. What do you know about iodine deficiency disease?

17. Is iodizing salt something you would like to do in the future?

18. What prevents you from iodizing your salt?

19. If money were not an obstacle, would you want to have your salt iodized?

20. What do you think would be the best way to iodize salt for you and other local farmers?
   (Do not read options to the Participant)
   1- backpack sprayers
   2- iodine drip method
   3- large factory
   4- other________
   98- I don’t know
   99- Refuse to answer

If participant gives a specific answer, ask 20a:

21a. Why do you think this would be the best way?

At end of interview, request a sample of salt for quality assessment of the salt produced via the new methods (Commune Anse Rouge, etc).
Appendix I

Crushed salt sample

This is an image of the traditional salt sample crushed to determine whether it would still be washed.
Appendix J

The Wheel Model for IDD Elimination Program Development

The following model was adapted from the model given by Hetzel and Pandav in 1994 (74). This model divides the process of formulating successful national program development and implementation into 6 distinct steps, beginning with an assessment of the scope of IDD problems facing the population. This includes consideration of factors such as IDD prevalence and distribution, along with assessing challenges to iodine consumption such as the country’s salt situation.

Following an adequate national assessment, communication between private and public bodies should lead to a consensus plan, which has the support of the government. Successful implementation of the plan requires many components such as appropriate training to involved parties, cooperation of the salt industry, and appropriate monitoring and evaluation in order to gauge the effect of implementation.

The wheel model emphasizes the iterative nature anticipated in interventions to reduce IDD. For more detailed information please refer to the guide assembled by WHO for program managers for assessing and monitoring IDD elimination (20).

The Wheel model for IDD Elimination. Adapted from Hetzel and Pandav (1994).
References

[34] Organization WH. Recommended iodine levels in salt and guidelines for monitoring their adequacy and effectiveness. 1996.