Health benefits of seafood for the prevention and management of chronic conditions: A systematic review

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**Glossary of Terms**

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<tr>
<th>Abbreviation</th>
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<tr>
<td>AD</td>
<td>Alzheimer's Disease</td>
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<tr>
<td>ADHD</td>
<td>Attention deficit hyperactivity disorder</td>
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<td>ALA</td>
<td>Alpha-linolenic acid</td>
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<td>AR</td>
<td>Allergic Rhinitis (hay fever)</td>
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<td>BMI</td>
<td>Body mass index</td>
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<td>CESSH</td>
<td>Centre of Excellence Science Seafood &amp; Health</td>
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<tr>
<td>CF</td>
<td>Cystic fibrosis</td>
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<td>CHD</td>
<td>Coronary heart disease</td>
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<td>COPD</td>
<td>Chronic obstructive pulmonary disease</td>
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<tr>
<td>CVD</td>
<td>Cardiovascular disease</td>
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<td>DHA</td>
<td>Docosahexaenoic acid</td>
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<td>EPA</td>
<td>Eicosapentaenoic acid</td>
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<td>FSANZ</td>
<td>Food Standards Australia and New Zealand</td>
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<td>GI</td>
<td>Glycaemic index</td>
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<td>HDL</td>
<td>High density lipoproteins</td>
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<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
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<td>LDL</td>
<td>Low density lipoproteins</td>
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<td>MI</td>
<td>Myocardial infarction</td>
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<tr>
<td>n-3s</td>
<td>Omega-3s (PUFAs)</td>
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<tr>
<td>NHMRC</td>
<td>National Health &amp; Medical Research Council</td>
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<tr>
<td>NSAID</td>
<td>Non steroidal anti inflammatory drugs</td>
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<tr>
<td>Omega-3s</td>
<td>Omega 3 poly unsaturated fatty acids</td>
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<tr>
<td>Omega-6s</td>
<td>Omega 6 poly unsaturated fatty acids</td>
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<tr>
<td>PUFAs</td>
<td>Poly unsaturated fatty acids</td>
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<tr>
<td>RA</td>
<td>Rheumatoid arthritis</td>
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<td>RDI</td>
<td>Recommended daily intake</td>
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<td>SFA</td>
<td>Saturated fatty acids</td>
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<td>TG</td>
<td>Triglyceride</td>
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<td>T2DM</td>
<td>Type 2 diabetes mellitus</td>
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<tr>
<td>VHDL</td>
<td>Very high density lipoproteins</td>
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Non-Technical Summary

2013/711 Health benefits of seafood for the prevention and management of chronic conditions: A systematic review

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OBJECTIVES:
The objectives of the project are:
1. To conduct a systematic review of the health benefits of seafood in relation to chronic conditions.
2. Present evidence from systematic review by chronic condition as
   • summary dot points and
   • text bites in layman’s language (that could be used directly by the industry).

METHODS:
A systematic review of literature was conducted using a comprehensive research strategy to identify evidence supporting the health benefits of seafood for the prevention and management of chronic conditions. A total of 526 publications met the selection criteria based the list of terms within the search strategy. Two reviewers independently reviewed and assessed each publication and rated the strength of evidence based on the National Health and Medical Research Council (NHMRC) Hierarchy of Evidence. The ratings of the two reviewers were then compared and those with different ratings were discussed and an agreed level of evidence assigned. A total of 281 publications had a sufficiently high level of evidence linking seafood to the prevention or management of chronic health conditions, thus were included in the review.

RESULTS:
Significant levels of evidence supported the regular consumption of seafood for the prevention and management of several chronic conditions. The strongest evidence is around the reduction of risk for all cause mortality, coronary heart disease (CHD), diabetes, mental health disorders, and nutrition related cancers. There is also strong evidence supporting the benefits of regular seafood consumption that is high in Omega-3s (n-3), for optimal brain
development and function, management of inflammatory conditions (such as arthritis, asthma and hay fever) plus control of inflammation associated with lung cancer and chronic pulmonary obstructive disorder (COPD), a common condition associated with impaired lung function.

Evidence shows the regular consumption of seafood high in Omega-3s delays the onset of Alzheimer’s disease (AD) in susceptible people and slows the progression of the disease in those already affected. There is emerging evidence supporting a seafood rich diet for people with cystic fibrosis (CF), kidney disease, liver disease and osteoporosis. Further, eating seafood as the main protein source can provide significant benefits in the dietary management of overweight and obesity.

There are many health benefits that can be gained from ingesting Omega-3s either through eating seafood or via supplementation. However, seafood also contains many nutrients that help the body to perform efficiently and effectively. These include:

• lean protein for cell repair and energy
• vitamin D and calcium for bone and teeth health
• calcium for muscle, heart and nerve function
• selenium to prevent cell damage and promote healing and immune function
• iodine (together with selenium) to regulate thyroid function and metabolism
• iron to help the blood carry oxygen to cells and for energy production and
• zinc to aid healing and for normal growth and development.

CONCLUSIONS:
This report provides a summary of evidence supporting the health benefits of seafood for the prevention and management of chronic conditions. A balanced diet high in seafood, aids in the prevention and management of many of the common chronic conditions affecting people today. The promotion of healthy eating should be integral to health promotion initiatives across the lifespan, not only to improve better long term health outcomes, but also to reduce the significant health care costs associated with the high prevalence of nutrition-related chronic conditions in Australia and around the world.

OUTCOMES ACHIEVED TO DATE
• Systematic review of literature on the health benefits of seafood for the prevention and management of chronic conditions.
• Evidence about the links between seafood and chronic conditions presented in layman’s language of seafood to a number of common chronic conditions affecting humans.
1.0 INTRODUCTION

1.1 Seafood and Health
In the 1950’s it was noted that Eskimos native to both Greenland and Alaska had a low incidence of heart disease despite having a diet high in oil. They also had a lower incidence (new cases) and morbidity (existing cases) of coronary heart disease (CHD). The causal nutrient thought to be ingested daily by all of these populations was Omega-3s from seafood. Since this discovery in the 1950s, there has been intense interest in finding what other health benefits could be gained from marine sourced Omega-3 long chain polyunsaturated fatty acids (PUFAs) (Omega-3s).\textsuperscript{1} We now know that the consumption of oily fish, seafood and fish oils have been positively linked with brain development, cognitive function and a reduced risk of many chronic conditions including coronary heart disease, some cancers, diabetes, arthritis, dementia and Alzheimer’s Disease.\textsuperscript{1-7}

Although much of the research has focussed on Omega-3s and its many health benefits, other nutrients in seafood also provide significant health benefits. For example, seafood is an excellent source of lean protein. The superior macronutrients combined with healthy Omega-3s, make seafood a superfood for health. In addition, seafood offers a wide array of highly bio micronutrients. In fact, seafood is the best dietary source of many nutrients.\textsuperscript{6}

1.2 Seafood and Nutrients
The key nutrients in seafood that provide benefits to human health are Omega-3s, protein, vitamins A, B\textsubscript{12}, D and E, iodine, selenium, calcium, zinc and iron.

**Marine Sourced Omega-3s**
Evidence clearly shows the link between health benefits and consumption of seafood high in Omega-3s. These benefits include: brain and retinal (eye) foetal development; cognitive development; mental health improvements (depression, schizophrenia, dementia and attention deficit hyperactivity disorder (ADHD); lower risk of CHD and
protection against heart arrhythmia; plus greater arterial plaque stability and anti-thrombotic properties. There is also evidence of the role of Omega-3s in maintaining immune function and reducing inflammation for the treatment of all forms of inflammatory arthritis. Oily fish are the richest source of Omega-3s. The two Omega-3s with proven health benefits are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The most abundant source of EPA and DHA are marine based sources. It should be noted that there is another Omega-3 fatty acid that offers some health benefit being alpha-linolenic acid (ALA), which is found in some plants. ALA must be converted to EPA and DHA after ingestion to be of use to the body. Herein lies the problem. Conversion rates of ALA to EPA and DHA are typically very low at around 3-8% making it very difficult to consume enough plant-based ALA to gain any substantial benefit. Clearly the consumption of Omega-3s from seafood is the best way to gain many additional health benefits.

For those who do not or cannot eat seafood, Omega-3 fortified foods and supplements are, however, recent research indicates that there are dramatic variations in the benefits offered from these products. For example, the shelf life of Omega-3 fortified foods and supplements have been questioned in light of their susceptibility to oxidation. By-products of oxidation such as peroxides, present safety concerns to humans. Eating seafood is the best way to gain the significant health benefits offered from Omega-3s. Those choosing to get their Omega-3s from supplements or fortified foods should make sure they consider if the products are from reputable sources, been stored correctly and are well within their use by dates.

*Protein*

Approximately half of the human body’s dry weight is comprised of protein. It is essential for human health and survival plus is a vital macronutrient that must be consumed regularly to meet the needs of the human body. Proteins are large molecules that serve as foundations for most of the body’s cells. They are vital for the development and maintenance of muscle, blood, skin and bone.
Protein plays an important role in antibody production, regulation of body composition, glucose metabolism, satiety, cell signalling, gastrointestinal health, bacterial flora and digestive function. It also provides the basis for production of some enzymes and hormones such as adrenaline, thyroid hormones and insulin.

Protein is a valuable source of energy. Animal sourced dietary proteins tend to be complete sources of protein; that is, they contain the full complement of essential amino acids, the building blocks of all proteins. Fish protein tends to be high in lysine, sulphur containing amino acids and threonine: essential amino acids that are limited in cereal-based diets. Evidence suggests that marine proteins are superior to other protein sources and offer some protection against many lifestyle diseases (overweight/obesity) due to their amino acid compositions. Furthermore, consumption of seafood protein has been positively associated with increased insulin sensitivity (in diabetics), reduced inflammation and lower blood pressure.

**Vitamin D**

Vitamin D is important in regulating calcium and phosphorous in bone mineralisation. It is also vital to thyroid function, insulin production, immunity, skin conditions, muscle strength and has been linked to the prevention of some cancers.

Widespread awareness of the causal link between sun exposure and skin cancer in Australia and New Zealand has diminished the amount of vitamin D that the general population obtains from the sun. Sunscreen and clothing act as barriers preventing not only sun damage but also the synthesis of vitamin D. Vitamin D deficiency and rickets (osteomalacia) are current health concerns across Australia and New Zealand. At risk populations include dark-skinned individuals, seniors, people with limited mobility and those who cover themselves when outdoors.

The food chain of marine animals tends to concentrate vitamin D and makes seafood the best dietary source of vitamin D. Prevention of vitamin D deficiency can be achieved with a diet high in oily fish together with limited sunlight exposure (around 10 minutes each day).
**Iodine**

Iodine is vital for the effective functioning of the thyroid gland and for thyroid hormone production. The thyroid facilitates normal growth, metabolism, cell oxygen consumption and the development of the central nervous system. Up until the early 1990s, the iodine status of Australians was satisfactory, however the iodine intake of the Australian population is now considered inadequate.

Iodine is found in most seafood, with shellfish containing the most abundant quantities. Fish and seafood have the highest concentration of iodine relative to other foods commonly consumed. Regular seafood consumption as a part of a healthy diet will improve iodine status.

**Selenium**

Selenium is protective against oxidative stress, which is a primary cause of cellular damage. It also assists in regulating the function of the thyroid (together with iodine) and supports healthy immune function. Selenium is present in most finfish. Selenium in fish is highly bio suggesting that fish is a superior source of dietary selenium relative to other sources.

In addition to the nutritional benefit of selenium consumption, emerging research suggests that selenium acts as a counteractive agent to mercury. It is possible that methylmercury accumulation in some fish populations may be moderated by selenium.

**Calcium**

Calcium is important for developing and maintaining bones and teeth, as well as supporting healthy function of muscles, nerves and the heart. Skeletal calcium serves as a reservoir for the supply of calcium to the body when required. If calcium is not consumed regularly these stores are depleted affecting bone health. Adequate dietary calcium is required throughout life to prevent loss of bone mineral density, fragility fractures, osteopenia and osteoporosis.
Bony fish such as sardines and tinned salmon are rich in calcium. The ingestion of at least 250g of seafood per week (2-3 serves) has been associated with greater bone mineral density.

Excessive dietary fibre intake and alcohol use can interfere with calcium uptake in the body. Effective calcium absorption also depends on adequate levels of vitamin D within the body.

**Vitamin B₁₂**

Vitamin B₁₂ is important to DNA synthesis (cell replication), red blood cell production and neurological function. Deficiency of vitamin B₁₂ is associated with megaloblastic anaemia (loss of red blood cells), nervous system disorders, myelopathy (spinal cord disease), memory impairment, dementia, depression and cerebrovascular (blood vessels that supply the brain) disorders. Clams, octopus, oysters, fish and fish roe are excellent sources of vitamin B₁₂. Researchers have identified that dietary vitamin B₁₂ sourced from fish is more bio than that from meat and eggs.

**Vitamin A**

Vitamin A plays an important role in supporting normal vision, reproduction, bone growth and immune function. It is also essential to healthy respiratory and urinary tract linings, and to the health of skin and mucous membranes.

Most fish and shellfish contain vitamin A, with the best marine sources being oily fish. Animal sourced vitamin A (retinol) is efficiently absorbed and used by the body. Plant sources of vitamin A (β-carotene) are less efficiently absorbed.

**Vitamin E**

Vitamin E is a highly efficacious antioxidant that is important to the skin, nervous system, heart and circulatory system. Vitamin E protects vitamins A and C by preventing their oxidation. The highest marine source of vitamin E is oily fish.
**Zinc**

While only small amounts of this essential trace element are required, zinc acts as a catalyst for over 100 specific enzymes necessary for human metabolism. Zinc plays a role in optimal growth and development, and in the efficient functioning of the immune system. Zinc deficiency may result in stunted growth, vulnerability to infection and adverse pregnancy outcomes.

Zinc rich food should be consumed regularly so that optimal zinc levels are maintained in the body. Zinc binds to protein, therefore seafood - a source of both zinc and protein - optimises the body’s ability to use dietary zinc. Oysters are known to be one of the richest natural sources of zinc.

**Iron**

Iron plays a vital role in the transportation of oxygen throughout the body in the blood and is associated with growth, healing and immune function. It is also critical for energy production and cell replication within the body. Research suggests that many Australian women are not consuming adequate levels of iron, particularly during important life events such as pregnancy and menopause. Increasing the consumption of iron rich seafood within a balanced diet can play an important role in addressing this imbalance. Furthermore, the body more readily uses iron found in seafood than plant sources.
Summary

In summary, Omega-3s are essential for human health. Humans cannot make them in sufficient amounts so they need to consume them everyday. Seafood is the best nutritional source of Omega-3s with evidence of health benefits to humans. However, there is much more to seafood than just Omega-3s. It is a superfood providing an array of nutrients that help to keep us healthy.

Seafood is a great source of:

- lean protein to build strong muscles and bones
- vitamin D for bone strength and healthy immune systems
- iodine essential for thyroid function, growth and for the nervous system
- selenium to protect cells, regulate thyroid function and support our immune system
- calcium for bone growth and prevention of osteoporosis
- vitamin B12 for blood production, cell development, and brain and nervous system function throughout life
- vitamin A for heart, eye, kidney and lung health, plus cell production and function
- vitamin E for smooth muscle growth, brain function, protection of cells from damage and to help the body to use Omega-3s
- zinc for normal growth and to help the body to use protein
- iron to allow the body to transport oxygen in red blood cells, for energy production and for growth, healing and immune function.
2.0 METHODS

A research associate experienced in seafood and health systematic reviews conducted an initial literature search and developed a list of possible search terms. The research team associated with this project reviewed the search terms and consulted a senior librarian to develop a comprehensive search strategy. The search strategy was informed by the following key terms: seafood, health, specific and generalised chronic conditions, health benefits and nutrition. Search terms were used individually and in combination. The search strategy was used to guide the systematic review of evidence supporting the health benefits of seafood for the prevention and management of chronic conditions.

Using the search strategy, published peer-reviewed articles (in English) were sourced from the following databases: Archive of Life Sciences; Proquest; PubMed; Science Direct; Taylor and Francis; The Cochrane Collaboration; Web of Knowledge; Web of Science; and Wiley Interscience. Other sources of information searched were: national and international seafood-based databases; seafood industry websites or databases; major national and international academic libraries; electronic sources of information (e.g. Google, Google Scholar, international websites); Departments of Health within Australia; and educational institutions.

2.1 Implementation of the Search Strategy

The search strategy identified 526 publications that met the search criteria. The full version of each article was sourced and an Endnote database file created of these references. Key search words were linked to each reference in Endnote to assist in sorting and summarising the published evidence.

Publications were then independently reviewed by two trained researchers, one an accredited dietitian and the other a very experienced reviewer who has completed the Cochrane Systematic Review training program (considered to be the gold standard for the conduct of systematic reviews).
The NHMRC Evidence Hierarchy was used as the framework for assessing the 526 journal articles (www.nhmrc.org.au) identified as meeting the criteria for possible inclusion in this review. The NHMRC Evidence Hierarchy framework is a valid tool for the effective management and critical review of large amounts of evidence.

The levels of evidence outlined in the NHMRC framework for assessment include:

- I - high level systematic reviews - randomised control trials and similar studies
- II - randomised controlled trial
- III-1 - pseudo-randomised controlled trials
- III-2 - comparative studies with concurrent controls
- III-3 - comparative studies without concurrent studies and
- IV - case series with either post-test or pre-test/post test outcomes.

Following the assigned level of evidence to each study by the two researchers (independent of each other), their assessments were compared. Where differences in the level assigned was evident, the two researchers discussed the reasons for their assigned score and made a joint decision about what evidence level should be assigned to each of these articles. The articles were then sorted by health or chronic condition, critically reviewed and the evidence summarised. The main outcomes of each of the publications included in the systematic review are stated in point form in the results section of this report. A total of 281 articles met the criteria thus were included in the review.
3.0 RESULTS OF SYSTEMATIC LITERATURE REVIEW

Key findings from the systematic literature review are presented herein by either health or chronic conditions. Evidence for each chronic condition consists of a general summary of evidence (boxed) followed by a list (in dot point form) of the main outcomes of each of the studies included in this review. References are listed at the end of this report. Only those studies with strong and credible scientific evidence (using the NHMRC Hierarchy of Evidence levels as a guide) are included in this review (see the methods section).

3.1 All Cause Mortality - Summary of evidence

There are significant risk reductions in all cause mortality associated with the consumption of 1-2 serves of seafood each week especially for: coronary health diseases (CHD); inflammatory conditions; neurodegenerative diseases; mental health and behavioural disorders; immune responses; and some cancers.

Health benefits are gained from ingesting Omega-3 polyunsaturated fatty acids (Omega-3s) found in abundance in most seafood, particularly oily fish. The Omega-3s that provide benefits are EPA and DHA. The best dietary source of EPA and DHA is seafood. Seafood is also a readily digestible source of lean protein and is a good source of vitamin D, selenium and iodine. Evidence shows that individuals who eat one or more serves of seafood per week (as part of a healthy diet) report a higher level of health compared with non-seafood eaters.

**All Cause Mortality – Main outcomes of studies**

- Regular fish and Omega-3 consumption is associated with a significant reduction of risk of total mortality. One to two serves of fish per week, especially those high in Omega-3s, decrease the risk of total mortality by 17%.  

- Observational evidence has shown that higher circulating individual and total Omega-3 levels are associated with lower total mortality, especially CHD death, in older adults.
• When used as a secondary prevention strategy, Omega-3s appear to modestly reduce all-cause mortality and restenosis (recurrence of blocked arteries or heart values).  

• Early supplementation of 1 g/d of Omega-3s after a myocardial infarction (MI) is recommended to reduce the risk of all-cause mortality.  

• There is clear evidence that Omega-3s (particularly EPA and DHA) are beneficial to human health. Evidence shows they exert benefits on cardiovascular health, inflammatory disorders, neurodegenerative diseases, mental health, behavioural disorders, immune responses, age related factors and some cancers.  

• The individual metabolic and physiological effects of EPA and DHA vary in the body.  

• The body processes marine sourced Omega-3s more efficiently than supplements.  

• The health benefits of seafood consumption go beyond those derived from the Omega-3 PUFA, with seafood also providing high quality protein, vitamin D, selenium, iodine and other bioactive components.  

• Cross sectional data shows that individuals who consume fish at least once a week have higher self-reported general health.  

• Evidence strongly supports the establishment of a RDI (Recommended Daily Intake) of Omega-3s.  

• The 2-3 serves of seafood/fish recommended each week should include at least one serve high in Omega-3’s in order to attain sufficient Omega-3s for human health.  

• Many (USA) adults are not consuming the recommended levels of Omega-3s in their diet. Governing authorities should consider supplementation in food or the promotion of fish oil capsules to assist the population to meet the recommended intake levels.
3.2 Alzheimer’s Disease (including dementia, cognitive function, ageing) - Summary of evidence

A diet high in fish, nuts, salad dressings, poultry, tomatoes, fruit, cruciferous (e.g. broccoli, brussels sprouts, cabbage) and dark green leafy vegetables is strongly associated with a lower risk of AD. Post mortem examinations of the brains of people with AD show a lack of DHA in the grey matter. Evidence shows that eating at least 2 serves of Omega-3 rich seafood each week reduces the risk of dementia, delays the onset of AD in susceptible people and slows cognitive decline. A balanced diet high in seafood has the potential to significantly reduce the public health burden of AD and contribute to healthy ageing.

Alzheimer’s Disease - Main outcomes of studies

• Research has revealed that a diet high in fish, nuts, salad dressings, poultry, tomatoes, fruit, cruciferous and dark green leafy vegetables is strongly associated with a lower risk of AD. 25

• Reduced risk of dementia is thought to be associated with the consumption of marine sourced Omega-3s: EPA and DHA. 26

• Post-mortem examinations have revealed that the brains of persons with AD contain less DHA in the grey matter of the frontal lobe and hippocampus. 27

• Large population based studies consistently reveal that Omega-3s retard cognitive decline over time. 28

• Elevated levels of lipid peroxidation have been observed in people with mild cognitive impairment and AD. Higher intakes of EPA and DHA appear to reduce lipid peroxidation amongst the elderly. 29

• Dietary Omega-3s are shown to be beneficial in balancing the ratio of Omega-3s to Omega-6s in the brains of normal subjects, thereby reducing the potential of damage to the brain. 26

• Emerging evidence suggests that genetic variations may influence the effect of EPA and DHA on cognitive decline. 30
• Promotion of the evidence to increase the consumption of sustainable seafood as part of a healthy diet has the potential to significantly reduce the human and public health burden of AD in the future. ²
• Evidence supports 2-3 serves of fish each week can prevent cognitive decline. ³¹
• Omega-3s promote active cognitive function in seniors. ³²
• In post menopausal women, high levels of EPA and DHA in red blood cells is associated with reduced atrophy of the brain during normal ageing. ³³

3.3  Arthritis - Summary of evidence
Seafood high in Omega-3s is beneficial in the management of inflammation within the body. Arthritis is a condition that results in significant inflammation around the joints of the body. It is often painful and extremely debilitating, impacting on a person’s ability to do everyday activities. Moderate to high intake of oily fish high in Omega-3s appears to be protective against osteoarthritis and rheumatoid arthritis (RA). Evidence supports daily consumption of oily fish such as fresh salmon, mackerel, herring or sardines for this debilitating condition. Daily ingestion of fish oil also provides significant benefits to those with RA. Fish oil (1000 mg/day) is currently used as an adjunct to approved medications for arthritis and can enhance the effectiveness of conventional RA treatments.

Fish oil supplementation for people at risk of developing or who have arthritis, should be prescribed by a medical practitioner as part of an overall medication management plan.

Arthritis - Main outcomes of studies
• Evidence shows that fish intake is beneficial in the management of inflammatory diseases. ¹, ³⁴
• A number of molecular mechanisms demonstrating the anti-inflammatory effects of Omega-3 PUFA have been proposed. ³⁵
Adequate levels of Omega-3 PUFA are important for appropriate immune system responses.  

Dietary intakes of Omega-3s are associated with lower levels of inflammation. Supplementation of 1.25 g/day of Omega-3 PUFA for four months significantly lowered levels of inflammatory molecules.

Moderate to high intake of fish appears to be protective in RA. An increase of 30 g of oily fish per day (8 g fat/100 g fish – fresh salmon, mackerel, herring; processed mackerel herring, sardines) has been associated with a 49% reduced risk of developing RA.

Dietary fish oil supplementation has demonstrable benefits for RA and other inflammatory/autoimmune conditions (e.g. bowel disease and immunoglobulin A nephropathy) and may also reduce pharmacological dosages required to treat RA.

Supplementation of Omega-3 PUFA in children with juvenile idiopathic arthritis reduces inflammatory responses, clinical manifestations and the required doses of non-steroidal anti-inflammatory drugs (NSAID).

Ingestion of Omega-3 fatty acid supplements has consistently shown improvements in joint tenderness and swelling, amount and duration of morning stiffness and disease activity in those with RA.

Fish oil is currently used as an adjuvant to approved medications for arthritis and studies support its efficacy in conjunction with NSAIDs. Recent research shows that supplementation of the Omega-3 fatty acid EPA enhances the effectiveness of conventional RA treatments. While consumption of fish and fish oil does not prove efficacious in all cases, some individuals have been able to discontinue or reduce NSAID therapy while continuing fish oil ingestion.

1000 mg/day of Omega-3s significantly reduced triglyceride levels in patients with active RA.
3.4 Asthma, Coronary Obstructive Pulmonary Disease, Allergic Rhinitis and Food Allergies - Summary of Evidence

Evidence supports the anti-inflammatory benefits of a diet rich in Omega-3s. This is true for asthma where Omega-3s reduce inflammation by positively impacting on lipid profiles. Recent research suggests that eating fish, seafood or supplementing n-3 PUFA during pregnancy may protect some children from asthma, eczema and food allergies. Fish consumption in the first year of life is associated with a reduced risk of asthma and allergic rhinitis (AR) (hay fever) in childhood. Children who eat fish at least once a week have a reduced risk of respiratory conditions compared with children who do not each fish. Children should be encouraged to eat a varied and balanced diet with at least one serve of oily fish each week.

Asthma, COPD, Allergic Rhinitis and Food Allergies - Main outcomes of studies

- An Omega-3s rich diet reduces inflammation associated with asthma by positively manipulating lipid profiles. 47
- Recent research suggests that eating fish, seafood or Omega-3 supplements during pregnancy may protect some children from asthma 48-51 eczema and food allergies. 50
- Fish consumption in the first year of life is associated with a reduced risk of asthma and allergic rhinitis in childhood. 52, 53
- Epidemiological studies in Australia reveal that school children who eat fish more than once a week have one-third the risk of airway hyper-responsiveness compared with children who do not eat fish regularly. 54
- Diets rich in Omega-3s, from either dietary sources or supplements, are associated with a reduced risk of asthma and airway diseases. 49, 51, 55, 56
- Consumption of highly processed fish sticks during pregnancy significantly increases asthma risk in children (odds ratio 2.04). This negative outcome is thought to be associated with the trans fat content of the processed fish sticks. 48
Emerging evidence indicates that Omega-3 supplementation can improve the pulmonary function in athletes undertaking intense physical training.\textsuperscript{57}

Observations have shown that adherence to a Mediterranean diet pattern during pregnancy and childhood (which includes fish) may have protective effects from asthma and allergic disorders in childhood.\textsuperscript{58}

### 3.5 Attention Deficit Hyperactivity Disorder and Other Behavioural Issues In Children - Summary of evidence

Almost 4 in 100 children in Australia have ADHD. Research has shown that children with ADHD often exhibit poor behaviours if they have low levels of circulating Omega-3s. Diets high in Omega-3s have resulted in improvements in the behaviour of children with ADHD. Omega-3s may also assist in the management of co-morbidities associated with ADHD such as mood and impulsivity disorders, oppositional defiance disorder, obsessive-compulsive disorder and depression.

#### Attention Deficit Hyperactivity Disorder and other Behavioural Issues In Children - Main outcomes of studies

- Approximately 4 of every 100 children in Australia have ADHD (The Royal Children's Hospital Melbourne [www.rch.org.au]). Significant co-morbidities of ADHD include mood and impulsivity disorders, oppositional defiance disorder, obsessive-compulsive disorder and depression. Sixty percent of these remain throughout life.\textsuperscript{59, 60}

- Evidence of the role of seafood or fish oil supplements in the management of attention disorders such as ADHD is mounting.\textsuperscript{60-66} Diets high in Omega-3s have been shown to correlate with the marked improvement in the behaviours of children with ADHD.\textsuperscript{59, 60} Children with ADHD should, therefore, be encouraged to consume Omega-3s.\textsuperscript{67}

- Low levels of Omega-3s may contribute to adverse ADHD symptoms.\textsuperscript{68} Further research is required to confirm if Omega-3s could be an effective treatment for ADHD and what levels are required to provide positive outcomes.\textsuperscript{69}
• Australian children do not consume the recommended levels of Omega-3s (particularly DHA) required for optimum health benefits. This can be explained by the low consumption of seafood/fish in children.70

3.6 Brain Development and Function - Summary of evidence
DHA and EPA are polyunsaturated fatty acids, essential to the development of the brain during pregnancy and for optimal cognition as we grow. DHA is highly concentrated in the brain. DHA and EPA support the composition and function of the central nervous system. Adequate Omega-3 intake in the first year of life is particularly important. Fish intake has been linked to academic performance. Improvements are evident in processing speed, visual-motor coordination, perceptual integration, attention and executive function.

There is good evidence showing that cognitive ability is influenced by the ratio of Omega-3s (marine sourced) to Omega-6s (plant based) in the body. For example higher levels of Omega-3s compared with Omega-6s is predictive of improved cognition in children. Conversely, low levels of red blood cell Omega-3 is associated with poor cognitive performance in children.

A diet high in seafood is associated with reductions in depression, behavioural problems, mood and impulsivity disorders. There is emerging evidence that adequate levels of Omega-3s in early childhood and into adulthood may prevent or reduce aggression and hostility.

Headaches are one of the most common debilitating conditions in adults, particularly for daily sufferers. There is strong emerging evidence that a diet high in Omega-3s and low in Omega-6s can reduce the number of headache days per month and reduce the duration of daily headaches in this population.
Brain Development and Function - Main outcomes of studies

- DHA and EPA are essential for foetal and neonatal brain development and maturation. Fatty acids accumulate quickly during periods of rapid brain growth and development during gestation (particularly in the last trimester) and in the first year of life. 71, 72

- During foetal development there is a large accumulation of Omega-3 PUFA in retinal membranes. There is also some evidence supporting maternal DHA intake as beneficial to the visual development of the foetus with benefits still detected in late childhood. 73

- Emerging evidence suggests that prenatal and childhood DHA intake can have beneficial effects on memory processing as children develop. Selection of seafood products with low levels of neurotoxic pollutants is necessary for this association. 74

- Fish intake (high in Omega-3s) has been positively linked to the cognitive and academic performance of school-aged students. 75, 76

- Improvements in processing speed, visual-motor coordination, perceptual integration, attention and executive function are evident with Omega-3 supplementation. 77

- Approximately 4 of every 100 children in Australia have ADHD. Significant co-morbidities of ADHD include mood and impulsivity disorders, oppositional defiance disorder, obsessive-compulsive disorder and depression. In 60% of cases of childhood ADHD, symptoms or difficulties remain throughout life. 59, 60

- There is emerging evidence for the role of seafood or fish oil supplements in the management of attention disorders such as ADHD. 60-66 Diets high in Omega-3s have resulted in a marked improvement in the behaviours of children with ADHD. 59, 60, 68 78 Therefore, children with ADHD should be encouraged to consume Omega-3 PUFA. 67

- Recent data indicated that 26% of Australians aged 16-24 years had a mental health disorder in the 12 months prior to the survey. 79 Adolescents may have additional compounding concerns of: poor diet (e.g. processed meats, sugars,
fats, and salt); adverse socioeconomic conditions; increased screen time; risky health behaviours; alcohol misuse; smoking and risky sexual behaviours.  

• Strong evidence supports the benefits of a diet high in Omega-3s as an adjunct therapy for people with depression, behavioural problems, mood and impulsivity disorders. Research has shown that low levels of red blood cell DHA have a positive correlation with clinical depression scores in children with juvenile bipolar depression.

• Emerging evidence supports adequate levels of Omega-3s in early development and into adulthood to aid in the prevention of aggression and hostility.

• A 12 week dietary intervention high in Omega-3’s and low in Omega-6’s significantly reduced the number of headache days per month and the headache hours per day in people who previously suffered from daily headaches.

• Cognitive ability is influenced by the ratio of Omega3’s to Omega-6’s in children. Higher levels of Omega-3s are predictive of significantly improved cognitive development.

• DHA is highly concentrated in the brain. DHA and EPA support the composition and function of the central nervous system. Animal studies have demonstrated loss of function of the brain and eye with DHA depletion.

• The risk of poor language development outcomes is increased with lower levels of DHA.
3.7 Cancer - Summary of evidence

High-level evidence supports fish consumption as protective in reducing the risk and mortality rate associated with certain nutrition related cancers (particularly in males). Specifically, evidence supports the association of a balanced diet high in Omega-3s with a significant reduction in the risk of ovarian, prostate, lung, breast and colorectal cancers. Emerging evidence supports the consumption of Omega-3s in reducing the incidence of pancreatic and bladder cancer plus colorectal adenomas. Inflammation associated with existing lung cancer can be reduced with regular ingestion of Omega-3s. Furthermore, at least 2 grams of EPA per day helps to maintain weight and muscle mass during chemotherapy.

Women are particularly susceptible to bone loss following menopause. There is an additional risk of bone loss for those women who are both menopausal and breast cancer survivors due to the effects of common cancer treatments. One study has found that supplementation of 4g/day of Omega-3s for 3 months was effective in reducing the amount of bone loss in these women. It is important to note that supplementation for menopausal women (including those who have had cancers) should be part of an overall treatment program overseen by a medical practitioner.

Cancer - Main outcomes of studies

- High fish intake has been associated with significant reductions in the risk of some nutrition related cancers, particularly ovarian and colorectal cancer. 86-91

- High-level evidence supports fish consumption as protective in reducing the risk of and mortality rates of cancer in males, particularly prostate and lung cancers. 92-97

- There is increasing evidence demonstrating an association between Omega-3 PUFA intake and a decreased risk of breast cancer. 90

- Epidemiological studies assessing the benefits of fish and seafood consumption associated with the risk of lung, prostate, breast, colorectal, ovarian, pancreatic,
skin (basal cell carcinoma), stomach and non-Hodgkin lymphoma show promising results. \textsuperscript{61, 92, 94, 98-102}

• Although further research is necessary, emerging evidence shows benefits from Omega-3 PUFA provision during the treatment of breast and colorectal cancer. \textsuperscript{102-106} Emerging evidence also supports the ingestion of pharmaceutical Omega-3 fish oil emulsion post gastric tumour resection to reduce damage caused by inflammation of the liver. \textsuperscript{107}

• Emerging evidence links high intakes of Omega-3 PUFA (particularly DHA) and non-fried fish to a lower incidence of pancreatic cancer. \textsuperscript{108} Evidence from cellular models indicates that DHA may affect the metastatic potential of bladder and pancreatic cancer cells. \textsuperscript{109}

• Adenomatous and hyperplastic polyps are often precursors for colorectal cancer. High intakes of Omega-3 PUFA have been associated with a reduced risk of colorectal adenomas in women. \textsuperscript{110}

• Intake of Omega-3 PUFA has been shown to increase the quality of life and functional status in patients with non-small cell lung cancer undergoing multimodality treatment. \textsuperscript{111} Supplementation of \( \geq 2 \) g/day of EPA provided benefits in maintaining weight and muscle mass during chemotherapy treatment. Positive associations were also observed between increased concentrations of EPA and rates of muscle gain. \textsuperscript{112, 113}

• Women who are both postmenopausal and breast cancer survivors are at risk of accelerated bone loss due to common cancer treatments. Short-term, high dose of fish oil (4g per day for 3 months) can reduce bone resorption in this population. \textsuperscript{114} (Supplementation should be part of an overall treatment regime developed and administered by a medical practitioner for these women).
Cardiovascular Diseases - Summary of evidence

The evidence is clear – fish and Omega-3s are beneficial to heart and cardiovascular health. As little as one serve of oily fish per week can reduce the risk of coronary heart disease and stroke. Two or more serves per week provides increased protection against all CVDs. Eating fish regularly significantly reduces the risk of heart attack. This is thought to be due, in part, to the impact that Omega-3s have in reducing triglyceride (TG) levels in the blood, which is beneficial to heart health. If there is no previous history of heart disease, this reduced risk may be as much as 35% (compared with those eating no fish). The reasons for this reduced risk include decreased cholesterol levels, lower blood pressure, lower resting heart rate, and softer artery walls. To gain the maximum benefits from eating fish it is best to either pan fry fillets or whole fish in a small amount of oil, or bake fish. (Remember, by deep-frying fish in oil, most of the health benefit is negated.) Oily fish such as salmon, mackerel and sardines provide the highest benefit.

Cardiovascular Diseases - Main outcomes of studies

- Fish and Omega-3 intake is beneficial to heart and cardiovascular health. One serve of fish per week reduces the risk of CHD and stroke. Two or more serves of fish each week provides increased protection against all CVDs.

- Supplementation of 1 g/day of Omega-3s has beneficial effects on a number of associated disease factors in patients with CHD. Some of these favourable effects appear to act in a dose-dependent manner to supplementation.

- Consumption of Omega-3s is associated with a reduced risk of CVD, cardiac events (heart attack) and mortality. For people with pre-existing coronary disease, increasing fish consumption or fish-oil supplementation is associated with reduced coronary mortality and sudden death.

- High-level evidence supports supplementation of Omega-3s for at least six months in people at high risk of CVD will decrease the risk of all types of cardiac events by 10%, cardiac death by 9% and coronary event by 18%.
• For subjects previously free of known CHD, consumption of ≥ 250 mg of Omega-3s daily is associated with a reduced risk of sudden cardiac death (35.1%) and total fatal coronary events (16.6%). 145

• Regular consumption of Omega-3s may decrease cholesterol levels. 146-76 179 Some studies suggest that supplementation of Omega-3s together with other cholesterol lowering methods (statins and phytosterols) have supplementary effects. 126, 143, 147, 148 Other researchers dispute the benefits of combining Omega-3s with statin therapy for reducing elevated cholesterol levels. 144

• High-level evidence demonstrates that supplementation of 1800 mg of EPA per day is effective at lowering the risk of a major coronary event in people with high cholesterol levels. 149

• Supplementation of 4 g/d of Omega-3s has been shown to significantly decrease elevated serum TG concentrations. 10, 126, 143 Similar results have been found in healthy men and women with fish and/or Omega-3s consumption, with beneficial effects on TG levels. 13, 150, 151

• Regular consumption of fish and Omega-3s found in fish and seafood can lower blood pressure in a dose dependent manner. 150, 152, 153 Supplementation of 3g of Omega-3s per day can significantly lower elevated blood pressure levels. 153

• Supplementation of Omega-3s has positive effects on blood vessels showing a significant reduction in arterial stiffness. 154

• High-level evidence shows that intake of Omega-3s has favourable, dose dependent effects on heart rate. 136, 155

• The risk of cerebrovascular disease is reduced with high levels of fish consumption. 188 This includes a reduced risk of death from stroke and all-cause ischemic heart disease (blockage of the arteries) in both men and women. Consumption of one serve of fish per week has shown to significantly reduce the incidence of ischemic stroke. 16, 118, 141, 156

• The effects of EPA and DHA supplementation appear to have gender specific responses on thrombotic risk factors. 157
• A high level of plasma fibrinogen is a known risk factor for both CHD and stroke. Emerging observational evidence indicates that high serum concentrations of Omega-3s may decrease plasma fibrinogen levels. 158

• Research has found that individuals who consume large amounts of fish have a 15% lower risk of heart failure than those who consume very little fish. 10,159

• High-level evidence shows that Omega-3 supplementation has been associated with a 34% decrease in the odds of developing postoperative atrial fibrillation. 160

• Fish and/or Omega-3s consumption is associated with lower levels of inflammatory markers indicating a lower risk of CHD 151,161,162 Consumption of 0.6 g/day of Omega-3s appears to be the optimal level for the maximal reduction of inflammatory level markers. 161

• People with human immunodeficiency virus (HIV) often develop dyslipidemia (abnormal amounts of lipoproteins) as a result of infections and treatment. This puts these patients at higher risk of CVD. Studies have shown that Omega-3 supplementation in conjunction with standard lipid lowering treatments enhances the reduction of serum TG levels in HIV patients. 163

• Consuming Omega-3s in place of saturated fatty acids (SFA) reduces CHD risk. When these PUFA are in the form of Omega-6s these beneficial effects are not observed. 164 Similarly, the shorter chain Omega-3 ALA does not exert the same cardiovascular health benefits as the longer chained EPA and DHA 165

• Consumption of fish, as part of the Mediterranean diet, has been associated with a lower risk of vascular events. 166

• The National Heart Foundation of Australia recommends that Australians consume 500 mg/d of combined EPA and DHA to lower their risk of CHD and 1000 mg/d for adults with existing CHD. For people with elevated TGs, a starting dose of 1000 mg of Omega-3s daily is recommended increasing to 4000 mg/d if appropriate. 167 (Higher levels of supplementation should be part of an overall
treatment and management plan developed and administered by a medical practitioner.)

• The benefits of eating fish can depend on the way it is prepared for consumption. Broiled or baked fish maintains the health benefits better than deep fried fish; with fried fish showing no association with a lowered risk of ischemic heart disease. Consumption of non-fried fish containing Omega-3s is associated with a lower odds ratio of atherosclerosis.

• Consumers of fish oil supplements and EPA/DHA enriched concentrates need to consider accuracy of content claims, oxidative stability, negligible levels of environmental contaminants and the appropriate accompanying presence of physiological antioxidants, when purchasing these products.

• Despite knowledge of the benefits of fish oil and favourable attitudes toward nutritional therapy, family physicians infrequently recommend fish oils to CVD patients.

• High levels of Omega-3s within the red blood cells of patients with peripheral artery disease are associated with lower levels of inflammation.

• The anti-inflammatory properties of Omega-3s may have a beneficial effect on chronic chagasic cardiomyopathy, an inflammatory disease of the heart.

• Lower levels of Omega-3s in the blood were associated with higher levels of atrial fibrillation in patients with chronic heart failure.

• A diet high in Omega-3s reduces TG levels, which is beneficial to heart health (reduces risk of CVD).

• Prescription-only EPA supplementation of 2g/day was effective in lowering very high level of TGs. This has implications for those at high risk of diabetes and CVD.

• A combination of statins with Omega-3 supplementation reduced the risk of subsequent adverse cardiovascular outcomes following myocardial infarction.
• Strong evidence supports a high dose Omega-3 supplementation (at least 1g/day) as a protective measure against cardiac death, sudden death and myocardial infarction in patients with existing CVD. ¹⁸⁰

• Use of Omega-3s following adverse cardiac events in a hospital setting has proven an effective adjunct therapy in reducing cardiac arrhythmic events. ¹⁸¹

• Some large studies have reported little or no association between Omega-3s and CVD risk. ¹⁸²-¹⁸⁴ However, many of these studies do not measure baseline Omega-3 levels or other dietary and health factors that impact on Omega-3s in the body. Other studies have used macro or self-reported measures which reduced the accuracy of findings. There is a call for the uniform implementation of standardised and valid measures of Omega-3s such as the Omega-3 Index. ¹⁸⁵

3.9 Cystic Fibrosis - Summary of evidence

Cystic fibrosis (CF) is a genetic condition mainly affecting the cells of the lungs, pancreas, liver and digestive systems. There is strong evidence that the regular consumption of Omega-3s in the management of CF can help to reduce inflammation and mucus levels.

Cystic Fibrosis - Main outcomes of studies

• High-level evidence suggests regular intake or supplementation of Omega-3s can provide some anti-inflammatory benefits for people with CF with relatively few adverse effects. ¹⁸⁶, ¹⁸⁷
3.10 Diabetes - Summary of evidence

Seafood is an excellent source of lean protein. It is also low in saturated fat and high in important Omega-3s. There is substantial evidence that Omega-3s play a key anti-inflammatory role in the body. Omega-3s also assist in the prevention and management of CVD, a condition many diabetics are highly susceptible to.

Seafood is second only to the sun as a source of Vitamin D. People with diabetes are more prone to deficiency of this vitamin, and can benefit from regular consumption of seafood as a part of a healthy diet. Evidence suggests that men should aim to consume 600mg of Omega-3s each day and women 500mg. Generally this equates to 2-3 serves (100g) of seafood each week. Seafood high in Omega-3s are sardines (canned or fresh), Atlantic salmon (canned or fresh), rainbow trout, bream, oysters, mussels and mullet.

Diabetes is often associated with high levels of TGs and general inflammation within the body. At least 2 g/day of Omega-3s can reduce TG levels in most people with nutrition-related diabetes. For those with uncontrolled diabetes, 4 g/day of ethyl EPA (a prescription only medication) can assist in the control of both high levels of triglycerides and inflammation.

Recent advances in diabetes research have shown a positive link between the genetic makeup of individuals and the level of benefit that can be gained from a diet high in Omega-3s. Further research in this area could lead to tailored Omega-3 supplementation that will maximize individual health benefits.

**Diabetes - Main outcomes of studies**

- Regular fish consumption should be part of a healthy diet for diabetic management.  
  188, 189

- A weak positive association has been observed between fish and Omega-3 FA intake, and the risk of developing type 2 diabetes mellitus (T2DM).  
  190
• Physical activity, a body mass index (BMI) less than 25, and a Mediterranean diet high in fruit, vegetables, carbohydrates with a low glycaemic index (GI) or high fibre, and 30-35% total fat (high in monounsaturated fatty acids and Omega-3s, and low in saturated fat) appears to be preventative against T2DM. Adherence to a Mediterranean diet pattern has been associated with a 12% reduction in the likelihood of developing T2DM.

• Regular fish consumption by women with T2DM was associated with a lower incidence of both CHD and total mortality.

• Albuminuria (albumin in the urine) is an indicator of kidney damage. Research has found that greater fish consumption was associated with a lower risk of macro albuminuria in people with diabetes.

• High-level evidence demonstrates that Omega-3 PUFA supplementation in people with T2DM can significantly decrease TGs and very-low density lipoprotein (VLDL) cholesterol levels. However, in some cases Omega-3 PUFA supplementation increased low-density lipoprotein (LDL) cholesterol levels. This may be a factor of the macro measurements used therefore this finding requires further investigation.

• Fish oil can impair glucose tolerance in individuals with high phospholipid Omega-6: Omega-3 ratios. Fish oil supplementation for these individuals should either be avoided or accompanied by decreases in Omega-6 dietary intakes.

• A large cohort study found that higher consumption of total, white or oily fish was associated with a 25% reduction in the risk of developing T2DM.

• At least 2 g/day of DHA+EPA significantly reduced triglycerides levels. 4 g/day of ethyl EPA (prescription medication) significantly reduced triglyceride levels and inflammation in patients with diabetes. It was particularly beneficial to patients with uncontrolled diabetes.

• Oily fish high in Omega-3s offers significant protection against T2DM.

• Research has shown a clear positive link between the influence of genetic variation on fasting glucose and fasting insulin levels in response to Omega-3
supplementation. This has implications for the development of tailored treatment of diabetes based on metabolic differences. Further research should focus on the influence of genes on glucose and insulin responses in the presence of Omega-3s. 202

3.11 Kidney Disease - Summary of evidence
There is evidence of a connection between the consumption of Omega-3s, and better kidney health. A diet high in seafood helps to maintain a healthy weight, which in turn, helps to regulate blood pressure and blood glucose, both implicated in kidney disease. As kidney disease is often associated with CVD, it appears that the consumption of Omega-3s may be beneficial for those with end-stage kidney disease.

Kidney Disease - Main outcomes of studies

• Emerging evidence has linked Omega-3 PUFA and fish intakes with the maintenance of kidney health. 203

• Patients with kidney disease are at high risk of developing CVD. Promising evidence suggests that the cardio-protective role of Omega-3 PUFA on CVD risk factors and disease factors, may be beneficial for patients with end stage kidney disease. 204, 205

• Omega-3 PUFA supplementation has beneficial effects on insulin resistance 206 and inflammatory markers in patients undergoing haemodialysis. 162

• Omega-3 supplementation of 3g/day in patients with end stage renal disease reduced their risk of CVD. 207

• A diet high in Omega-3s reduced systemic inflammation and improved lipid levels in renal transplant patients. 207, 208
3.12  Liver Disease - Summary of evidence
A balanced diet high in seafood offers real benefits in the prevention and management of diabetes and obesity, both primary risk factors for liver disease. The consumption of seafood as part of a health diet may help to prevent fatty liver disease (hepatic steatosis).

Liver Disease - Main outcomes of studies

- Emerging evidence suggests that Omega-3 PUFAs may be beneficial for the prevention or management of non-alcoholic fatty liver disease.\(^{209, 210, 211}\)

3.13  Maternal and Child Health - Summary of evidence
As expectant mothers know, good nutrition is vitally important for their own health during pregnancy and their baby's development. Nutrition is particularly important for the optimal development of the brain and central nervous system and Omega-3s play a very important role in both. In short, Omega-3s are essential to brain development during pregnancy, particularly DHA – the most important Omega-3 fatty acid for brain development. (These benefits continue after a child is born.)

Regular consumption of fish during pregnancy has been associated with decreased rates of premature delivery, increased birth weight and lower hypertension, all factors that improve long-term outcomes for infants. Some studies have shown that Omega-3s present in the breast milk of mothers who eat fish are associated with (healthy) infant weight gain, height, and BMI. Others have found that a mother’s fish consumption is linked with higher child development scores, improved language skills and sound visual development.

Pregnancy can be a time of heightened anxiety for expectant mothers. As noted, a balanced diet rich in Omega-3s is essential for good health but has the additional benefit of reducing high levels of anxiety during pregnancy.
Maternal and child health - Main outcomes of studies

• Evidence supports a diet high in Omega-3s as being beneficial to the health of women throughout the lifespan.\textsuperscript{212} This is most important during pregnancy and breastfeeding as maternal nutrition is important to development of the foetal and infant brain. \textsuperscript{213}

• Seafood is an excellent source of Omega-3s, which are essential for optimal foetal neural development. \textsuperscript{50, 214, 215} Positive associations exist between long chain Omega-3 PUFA supplementation and the neurodevelopment of the offspring. \textsuperscript{50, 216, 217} The ideal dose of Omega-3 PUFA, composition and ratio of EPA:DHA to maximise child development requires further investigation.\textsuperscript{218}

• High levels of fish intake during pregnancy have been associated with longer gestation, \textsuperscript{217} increased birth weight and lower rates of hypertension during pregnancy. \textsuperscript{50, 219, 220, 221, 222, 223}

• Observations show that the total amount of PUFA in a mother’s breast milk is positively associated with weight gain, height and BMI in premature infants. \textsuperscript{224}

• Omega-3 PUFA intakes during pregnancy may be beneficial on a number of infant birth outcomes. \textsuperscript{225}

• Prenatal long chain PUFA availability is influenced by maternal diet. Associations have been made between prenatal availability of long chain PUFA and the motor function of children at 7 years of age. \textsuperscript{226}

• Consumption of two salmon (high in Omega-3s) meals per week during pregnancy lowered inflammatory markers in offspring, which is associated with a decreased risk of CVD. \textsuperscript{227}

• Although further research is required, EPA and DHA supplementation may be beneficial for women with perinatal depression. \textsuperscript{66, 228} A small cohort showed that pregnant women with lower levels of Omega-3 PUFA were six times more likely to have antenatal depression than women with higher levels. \textsuperscript{229}
• Research has shown that the dietary patterns of girls and boys should be considered separately when assessing their intake of Omega-3s and thus in the development of targeted dietary interventions.  

• Greater maternal fish consumption has been linked to higher child developmental scores at 18 months, improved performance in language and visual motor skills, and visual development.  

• Deficit of DHA during pregnancy impacts adversely on neural development and gene expression. Adequate maternal intake of DHA is essential to the central nervous system development of infants.  

• Although cause and effect has not been established, a diet rich in Omega-3s can reduce high anxiety levels during pregnancy.  

• There are beneficial effects on child development of a maternal seafood intake of more than 340 g per week. This suggests that advice to limit seafood consumption could actually be detrimental. The risks from loss of nutrients to the foetus were greater than the risk of harm from exposure to trace contaminants in 340 g seafood eaten weekly.  

• Fish and seafood intake guidelines for women who are pregnant, may become pregnant or are breastfeeding need to be specific about fish species to ensure adequate intakes of Omega-3 PUFA and minimal intake of methylmercury. It appears that some pregnant women have limited knowledge of the benefits of Omega-3 PUFA intake during pregnancy.  

• Some fish and seafood are potential sources of pollutants such as methylmercury that may adversely affect pregnancy outcomes. Thus, advising pregnant women about fish consumption requires consideration of potential risks as well as benefits. There are national guidelines that seek to minimise any risk of consumption of fish and seafood during pregnancy. These guidelines note the health benefits far outweigh the minimal risk. However, not enough women of childbearing age are consuming adequate fish for health benefits.
### 3.14 Mental Health and Behavioural Conditions - Summary of evidence

There is an association between the consumption of Omega-3s from fish and mental health and/or behavioural issues. Frequent seafood consumption is associated with lower levels of depression. This is thought to be due to the ingestion of Omega-3s, iodine, selenium, zinc and Vitamin B12 – all found in seafood and often deficient in those with depression. Most studies support a balanced diet high in oily fish as a complimentary therapy for the prevention and management of mental health and behavioural conditions. Omega-3s are essential to the optimal function of the brain therefore oily fish should be included in diets for good mental health. Children and adults with behavioural issues often benefit from the additional fish oil supplements in their diet as they provide high doses of DHA, the type of Omega-3s that aids brain function.

In general seafood is good for mental health. People with a wide range of mental health conditions (e.g. depression, anxiety and bipolar disorder) who eat fish regularly, say it made them feel better and helped them manage their condition.

Anxiety and depression are two of the most common mental health conditions facing Australians today. There is good evidence linking a balanced diet high in Omega-3s with reduced depressive symptoms in both men and women. There is also evidence supporting the intake of at least 1.2 g/day of Omega-3s to reduce impulsivity, anger outbursts and other symptoms associated with borderline personality disorder, particularly in adolescents. There is good evidence supporting a diet high in oily fish (with or without fish oil supplements) for children and adults with ADHD.

It is important to note that, for these conditions, nutritional therapies should be part of a tailored treatment program administered by an appropriately qualified medical practitioner.
Mental Health and Behavioural Conditions - Main outcomes of studies

• An Australian survey found that approximately 20% of Australians aged 16 to 85 years reported a mental health disorder in the previous 12 months. 79, 238

• Fish consumption is associated with a significantly higher self-reported mental health status. 239, 240

• A mean daily intake of 10 g of seafood is linked to a lower prevalence of poor cognitive performance. 241

• Higher dietary intake of Omega-3s offers some protection against depression. 238

• Worldwide, there are significant negative correlations between fish consumption and depression (including post-partum), bipolar disorder and suicidal ideation. 239, 242-244

• Emerging evidence suggests there are benefits of Omega-3 PUFA supplementation on depressive symptoms in people with bipolar disorder. 235, 245, 246

• Adequate fish intake has a negative association with depressed mood, risk of recurrent depressive episodes and depressive symptoms. 120, 247, 248

• Emerging evidence shows supplementation of 1gm of Omega-3 PUFA a day in children with major depression significantly reduces depression scores. 249

• Omega-3 has a role in reducing impulsivity, psychiatric symptoms and outburst of anger in the treatment of borderline personality disorder. Nutritional strategies focussing on at least 1.2 g/day of Omega-3s should be explored as a minimally invasive treatment for adolescents with borderline personality disorders. 250, 251

• There is good evidence linking Omega-3 intake and reduced depressive symptoms in both men and women. 252, 253

• A growing body of evidence suggests a protective effect of Omega-3s against dementia. 254, 255, 255 Intake of at least one fish serve per week reduces the risk of Alzheimer’s disease. 256-258
• Changes to the traditional Western diets to include adequate levels of Omega-3s should be considered when developing or modifying food, health and dietary policies.  

3.15 Metabolic Syndrome - Summary of evidence

Metabolic syndrome refers to a condition where multiple risk factors for both CVD and T2DM occur together. The main risk factors are: abdominal fat; high blood pressure; low levels of ‘good’ cholesterol (high density lipoproteins - HDL); high levels of ‘bad’ cholesterol (low density lipoproteins - LDL); high levels of TGs; insulin resistance; physical inactivity and cigarette smoking. As seafood is beneficial in the prevention and management of both CVD and T2DM, there is good reason to believe that the consumption of seafood (particularly those high in Omega-3s) would be beneficial in the prevention, management and treatment of metabolic syndrome. Some studies have shown that a Mediterranean diet pattern, including fish, is associated with just such positive outcomes. Significant health benefits in adults were gained with supplementation of 2 g/day of Omega-3s.

Metabolic Syndrome - Main outcomes of studies

• Metabolic syndrome is a term used to describe a cluster of risk factors (abdominal obesity, dyslipidaemia, hypertension and insulin resistance) observed in an individual. With known beneficial effects of Omega-3s on some of these risk factors, it is likely they are beneficial in the management and treatment of metabolic syndrome.  

• Supplementation of >1 g a day of Omega-3s produced significant reductions in the serum triglycerides of patients with metabolic syndrome.  

• Adherence to a Mediterranean diet pattern (which includes fish) is associated with favourable effects on the components of metabolic syndrome.
• Improvements in endothelial function and arterial stiffness were evident in adults with metabolic syndrome after supplementation with 2 g/day of Omega-3s. Reduction in inflammation was also evident. 263

• DHA may help to prevent metabolic syndrome based on its impact on inflammation and insulin, however further studies are required to establish adequate doses required to reduce risk. 264

3.16 Osteoporosis - Summary of evidence
A group of conditions affecting the muscles and bones of the body are known as musculoskeletal conditions. One of the most common types of musculoskeletal problems is osteoporosis, an extremely painful and debilitating condition resulting in an increased risk of bone fractures. Common symptoms are joint pain and inflammation, stiffness, disability and deformity. Calcium and vitamin D, key ingredients in seafood, aid in the prevention and management of osteoporosis. Eating fish from an early age helps to lay down strong bones. Continual consumption throughout life maintains bone health with some evidence that Omega-3s reduce age-related bone and muscle loss.

Women are particularly susceptible to bone loss following menopause. There is an additional risk of bone loss in women who are both menopausal and breast cancer survivors due, in part, to the effects of common cancer treatments. One study has found that supplementation of 4g/day of Omega-3s for three months was effective in reducing the amount of bone loss in these women. It is important to note that supplementation for this group of women should be part of an overall treatment program overseen by a medical practitioner.
**Osteoporosis - Main outcomes of studies**

- Evidence shows that fish intake is beneficial in the management of inflammatory diseases.\(^1,\)\(^{34}\)

- A number of molecular mechanisms demonstrating the anti-inflammatory effects of Omega-3 PUFA have been proposed.\(^{35}\)

- Adequate levels of Omega-3s are important for appropriate immune system responses.\(^{36}\)

- Dietary intakes of Omega-3s are associated with lower levels of inflammation.\(^{265}\) Supplementation of 1.25 g/day of Omega-3 PUFA for four months significantly lowered levels of inflammatory molecules.\(^{37}\)

- There is some evidence that Omega-3’s reduce age-related bone and muscle loss.\(^{266}\) Women who are both postmenopausal and breast cancer survivors are at risk of accelerated bone loss due to common cancer treatments. Short-term, high dose of fish oil (4g per day for 3 months) can reduce bone resorption in this population.\(^{114,\)\(^{267}\)
3.17 Overweight and Obesity - Summary of evidence

Excessive weight is a risk factor for many medical and health conditions including CVD, diabetes, musculoskeletal condition and some cancers. The more excess weight a person has, the greater the risk of developing adverse health outcomes. Being overweight or obese can also make it more difficult to prevent, or manage conditions that may arise due to the additional stress that excess weight places on the systems of the body.

Protein has a superior affect on satiety. Seafood is a great source of lean protein that is readily absorbed by the body. This means you only need to eat a small amount each day to get the protein producing energy you need. A serve of 100-150 g of seafood is recommended, making it a very cost effective meal.

Seafood has a raft of essential nutrients that help the body and brain to function effectively. It also helps reduce inflammation associated with obesity making seafood the ideal choice for those wishing to become healthier. Inflammation is a common problem associated with obesity. This type of inflammation spreads throughout the whole body. A daily dose of Omega-3s (460mg EPA and 380mg DHA) offers real benefits in reducing systemic inflammation associated with severe obesity.

Overweight And Obesity - Main outcomes of studies

- Obesity as a major risk factor for CVD, T2DM, and some musculoskeletal conditions and certain nutrition-related cancers. \(^{268}\) Suggestions have been made that the development of some of these complications is tightly correlated with the chronic low-grade adipose tissue and systemic inflammation associated with obesity. Targeted interventions aimed at reducing weight through dietary modifications have had limited success with the overweight and obese population.\(^{269}\) However, recent research with severely obese, non-diabetic subjects found that supplementation of 460 mg of EPA and 380 mg of DHA each day improved adipose and systemic inflammation.\(^{270}\)
### 3.18 Possible Health Risks - Summary of evidence

**Pollutants:** Like any natural food source, there is potential for the presence of dioxins and other pollutants in seafood. Possible pollutants in seafood include mercury or other heavy metals. However, many high-quality studies have concluded that the level of these pollutants in fish and other seafood is generally very low, and that the potential health benefits of fish consumption outweigh potential risks. Furthermore, emerging evidence indicates that when selenium is present, it helps to counteract the effect of these pollutants. Further research is required to confirm this association.

Researchers have built a good understanding of the mineral profile of various species, meaning that it is possible to plan consumption to manage the small risk of pollutants such as methylmercury. In practical terms, this means limiting consumption of a small number of larger fish species. Food Standards Australia New Zealand (FSANZ) has clear guidelines to assist with these decisions. [www.foodstandards.gov.au](http://www.foodstandards.gov.au)

Women who are pregnant, may become pregnant, or are breastfeeding should pay particular attention to these recommendations, and infants up to six years should limit their consumption of some species (see [www.foodstandards.gov.au](http://www.foodstandards.gov.au) for guidelines). However, fish should not be avoided altogether, as it is the single best source of Omega-3s and other key nutrients that play an important role in foetal neural development, the development of small children and delayed onset of dementia as we age.

**Supplementation:** Fish oil supplements can provide benefits to those who either don’t or can’t eat seafood. They are also helpful when larger doses of Omega-3s are recommended to assist in the management of some chronic conditions (e.g. arthritis). However, it is essential that only high quality supplements from reputable sources are ingested, that they are stored according to instructions and are not ingested past their used by date. Low quality, poorly handled ingredients prior to encapsulation or fish oil past its’ used by date may pose a risk to human health.
Possible Health Risks - Main outcomes of studies

- A balance of risk-benefit in relation to the consumption of fish and seafood is recommended in the literature, taking into consideration meal size and frequency of consumption. $^{137, 271}$

- Guidelines are to assist people to make informed choices about the types and amount of seafood they ingest based on higher Omega-3 content and low mercury concentrations. $^{272}$

- Levels of dioxins and other pollutants in fish are low, and potential carcinogenic effects are outweighed by potential benefits of fish intake and should have little impact on choices or consumption of seafood. $^{15}$

- Fish low in mercury and high in Omega-3s are recommended. $^{273, 274}$ Light tuna has relatively low levels of mercury, and other fish, such as wild and farmed salmon and shrimp, contain very low levels of mercury. $^{275}$

- Fish containing the highest amounts of Omega-3s in the United States (USA) are farmed trout, farmed Atlantic salmon, Coho salmon, toothfish, Copper River salmon and sockeye salmon. $^{276}$

- Women of childbearing age should consult regional advisories for locally caught freshwater fish. The benefits of modest fish intake, excepting a few selected species, outweigh any potential risk. $^{15, 137}$

- Women who are pregnant, may become pregnant or are breastfeeding, as well as very young infants should avoid fish that may contain mercury. Consumption of fish and seafood should not, however, be avoided altogether as it is the predominant source of Omega-3s, which are essential for optimum foetal neural development. $^{214, 277}$

- Advances have made bio-monitoring a cost-effective public health tool for helping federal, state and local health agencies develop optimal dietary guidance. $^{278}$
• Selenium appears to have a role in counteracting mercury toxicity. There are suggestions that the selenium content in fish should be considered when conducting mercury risk assessments. 277 These findings require further investigation to confirm this association.

• Risk-benefit frameworks have been proposed as methods of determining optimal intakes of fish/seafood. 274, 275, 279, 280

• The level of oxidation in fish oil supplements is an important factor in the control of circulating lipoproteins. Highly oxidated products may be a risk to human health. Manufacturers should test the level of oxidation in the ingredients of supplements prior to encapsulation as a quality assurance measure. 281
4.0 CONCLUSIONS

This report focussed on summarising the best evidence around the health benefits of seafood for the prevention and management of chronic conditions. The benefits of marine sourced Omega-3s for general, heart and brain health are well established and generally well known. The strongest evidence is around the reduction of risk for all cause mortality, coronary heart disease, diabetes, mental health disorders, and nutrition related cancers. There is also strong evidence supporting the benefits of regular consumption of seafood that are high in Omega-3s, for optimal brain development and function, management of inflammatory conditions (such as arthritis, asthma and hay fever) plus control of inflammation associated with lung cancer and COPD, a common condition associated with impaired lung function.

Evidence is mounting in support of the regular consumption of seafood high in Omega-3s in delaying the onset of Alzheimer’s Disease in susceptible people and slowing the progress of the disease in those already affected. There is emerging evidence supporting a seafood rich diet for people with cystic fibrosis; kidney disease; liver disease and osteoporosis. Furthermore, eating seafood as the main protein source can provide significant benefits in the dietary management of overweight and obesity.

Less well recognised by the general population are the additional benefits that can be gained from eating seafood (particularly oily fish) as a source of Omega-3s rather than taking fish oil supplements. Seafood contains many nutrients (other than Omega -3s) that help the body to perform efficiently and effectively. These include: lean protein for cell repair and energy; vitamin D and calcium for bone and teeth health; calcium for muscle, heart and nerve function; selenium to prevent cell damage and promote healing and immune function; iodine (together with selenium) to regulate thyroid function and metabolism; iron to help the blood carry oxygen to cells and for energy production; and zinc to aid healing and for normal growth and development.
In summary, this systematic review of literature found that there is significant evidence supporting the effectiveness of seafood (including fish) as an adjunct therapy for the prevention and management of many common chronic conditions affecting people today. Therefore, healthy eating and dietary guidelines that include seafood as a major nutritional source, should be integral to health promotion initiatives across the lifespan, not only to improve better short and long term health outcomes, but also to reduce the significant health care costs associated with the high prevalence of nutrition-related chronic conditions in Australia and around the world.
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