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DRAFT

RECOMMENDATIONS FOR THE PREPARATION OF GUIDELINES FOR THE MANAGEMENT OF SEA WATER DESALINATION IN THE MEDITERRANEAN REGION

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Introduction

The present document has been prepared by the Secretariat on the basis of the policy and technical information available in the Mediterranean region and elsewhere. The document presents to experts and Governments' representatives a number of principles and ideas collated in the form of recommendations which may at a later stage be the basis for the preparation of Guidelines for the planning and the environmentally sound management of sea water desalination plants with special reference to the management of brine discharges.

In the intention of the Secretariat, the general objective of the Guidelines that may be prepared in the future is to guide Governments in the planning and managing sea water desalination plants in respect with existing international, regional and national practices and regulations in order to anticipate and minimize possible adverse effects on the marine environment.

The content of the document is to be considered as draft and subject to review, analysis and discussion by the Meeting.

The Meeting is therefore expected to confirm to the Secretariat the intention to prepare Guidelines and to review, revise and agree on the draft content of this document.

Regional and national water management and protection policy

1. National Water Management Policy

Desalination activities development is an integrated part of the national water resources management policy and especially the one related to the coastal water management, it must conform with the policies and standards contained in the coastal development plan (e.g. CAMP) of the local authority with jurisdiction in the area of the proposed development.

The construction of desalination plants to meet water supply needs may result in socio-economic growth-inducing impacts. Limited water in fact is often the major constraint to development in many parts of the coast. Therefore, new desalination projects in coastal areas could lead directly to new development and to a resulting increase in population migration to coastal areas. However, new developments helped by a new plant could in turn influence long-term regional goals. For example, desalination plants built in rural areas could lead to growth in these areas rather than within existing urban boundaries; desalination plants built in urban areas may also change the character of these areas.

Potential socioeconomic growth-inducing impacts should be considered for those communities that receive the water, as well as those where the desalination plants will be located. National environment authorities and local governments should consider, on a regional scale, the pros and cons of building a larger number of small plants versus a smaller number of larger ones. Growth-inducing impacts may be more significant for projects that operate for many years, as compared to those that are short-term projects for drought relief. National environment authorities should consider the potential long-term impacts of extending the life of projects that are presently intended for short-term use.

The most effective way to ensure proper implementation of desalination activities and other coastal development plans priorities in areas where desalinated water may need to be produced is to achieve these development priorities through zoning and other standard land.

Because public ownership and operation of desalination plants can also be expected to assist in ensuring that water allocations will occur in a manner that is consistent with the foregoing development priorities, national environment authorities may need to consider special or additional conditions in connection with any approvals it may grant for privately-owned desalination plants.

2. Regional and national marine environment protection Policy

The assessment report (UNEP(DEC)/MED WG.205/3) indicated that sea water desalination activities have potential adverse impacts on marine environment. This fact should be considered by the national environmental authority in relation to the national plan for the conservation of the environment and/or marine environment protection plan and regional commitments to prevent marine environment from Land Based Sources of Pollution.

Since sea water desalination activities are rather limited in the Mediterranean region, these activities are not usually included under the provisions of national environmental policy, regulatory institutions and legal framework. Consequently, it would be appropriate for Mediterranean countries to develop and extend the institutional and legal framework to cover sea water desalination activities.

The LBS Protocol adopted by the Contracting Parties to the Barcelona in 1996 provides for the maintenance, enhancement, and restoration of marine resources and biological productivity. According to article 5, “The Parties undertake to eliminate pollution deriving from land-based sources and activities, in particular to phase out inputs of the substances that are toxic, persistent and liable to bioaccumulate listed in annex I. To this end, they shall elaborate and implement, individually or jointly, as appropriate, national and regional action plans and programmes, containing measures and timetables for their implementation.” Annex I contains 30 sectors of activity to be considered, 13 characteristics of substances to be taken into account and 19 categories of substances for which action plans should be prepared. The sea water desalination activities could be covered by the sector entitled “Works which cause physical alteration of the natural state of the coastline” and category of substances “Non-toxic substances that may have adverse effects on the physical or chemical characteristics of seawater”.

Desalination of brackish water from inland wells is a common practice frequently used by Mediterranean countries to ensure the supply of soft water to small and medium sized industry and municipalities. These activities generate a small amount of brine waste which is either discharged inland (pond, sewer) or dumped into the sea using vessels. According to the 1995 Dumping Protocol, the latter practice should be discontinued.

Technical Recommendations to respond to national and regional policy requirements

Energy Use

Applicants for sea water desalination projects of desalination projects are encouraged to consider possibilities for cogeneration, alternative energy technologies, and technologies that reduce energy use. The applicants for sea water desalination projects should submit estimates of the projected annual energy use and the environmental impacts that will result from this energy production. For plants that will require significant new electricity generation, the provision of adequate offsets should be ensured if required. In these cases, applicants for sea water desalination projects should submit with the permit application evidence of compliance with air pollution control laws for emissions from the electricity generation.

Seawater Intake

For the intake of seawater, desalination plants can use either a pipeline in the sea or beach wells. Beach wells have the significant advantage of eliminating impingement and entrainment impacts. Applicants for sea water desalination projects are encouraged to use beach wells for seawater intake whenever feasible, and where the wells will not cause significant adverse impacts to either beach topography or potable groundwater supplies.

Use of Hazardous Chemicals

Applicants for sea water desalination projects are encouraged to select technologies and processes that minimize or eliminate the discharges of hazardous constituents into the Mediterranean sea. The owner should ensure that the least environmentally damaging options for feedwater treatment and cleaning of plant components are selected.

Combining Brine with Other Discharges

Applicants for sea water desalination projects should evaluate the options for combining brine discharges with discharges from a power plant or a sewage treatment plant. Combining the brine with power plant cooling water discharges is probably the form of sea discharge that will have the least damaging impacts because the brine would be diluted. Mixing with sewage treatment effluent may also be preferable to direct discharges of brine, but more information on the impacts on marine environment is needed.

When the brine is combined with other discharges, applicants should clearly identify the person or the body responsible for the monitoring of the discharges and for providing corrective measures for any adverse impacts that may occur.

Quality of Discharges

Applicants for sea water desalination projects should provide as much information as possible about the potential impacts on the marine resources deriving from the proposed discharges. This information may be obtained from pre-operational monitoring, monitoring results from other desalination plants, and pilot plant studies conducted before building a full-scale plant. The information should be reviewed by the national environment authorities in consultation with other competent bodies.

The national environment authority will consider the information contained in the discharge permit as part of its review of the coastal development permit application if available. The authorities should work together with the other competent bodies to ensure that the applicants will provide the pre- and post-operational monitoring information needed to

evaluate the marine resource impacts of the plant. The coastal development plan, if available, should require that 1) the national authority receive copies of all monitoring reports submitted so that the marine resource impacts of these plants may be evaluated and 2) the manager provides evidence to the national authority of permit renewals for discharges from the plant.

The national environment authorities should review the monitoring information provided by the desalination plant operator and, as a result, either strengthen existing regulatory requirements to minimize or eliminate adverse impacts possibly identified or modify the monitoring requirements in order to obtain more information on a particular problem.

If the national environment authorities believe that the monitoring activities are not adequate to evaluate the impacts on marine resources, then the permits should include additional conditions as needed.

Potential Growth of water demand

In evaluating a proposal for a desalination plant, the national environment authorities should consider whether the water provided will meet only the existing needs of the community or private development or will provide additional water supplies, which may allow opportunities for growth. Water supplies made available through a desalination plant should be no more than those that would support development potentially allowable under the coastal development plan, if available.

If an applicant submits a proposal to build a desalination plant to meet emergency water supply shortfalls, the authorities should evaluate the proposal to determine if the plant is designed in a manner that will allow for easy removal of the structure with minimal environmental impacts after the emergency has passed. The permit should include a condition that stipulates the time for which the permit is valid and that requires the owner to apply for a new permit to extend the life of the plant if required. The permit should specify the authorized capacity of the plant and the owner must subsequently comply with the capacity limitation stated.

Periodic Reviews of national sea water desalination plans

As part of the periodic reviews of national seawater desalination plans in water-short areas, the national environment authorities should consider water supply issues and potential growth-inducing impacts from water supply. National water resources conservation plans should encourage use of conservation and reclamation measures to reduce the need for new water projects. These plans should also specify the quantity of water supplies that will be needed for the planned level of development.

Environmental Impact Assessment

Applicants for sea water desalination projects of desalination projects should evaluate cumulative (overall) impacts in their Environmental Impact Assessment Reports. The national environment authorities will work with local and other competent agencies to consider the potential cumulative impacts of desalination projects under the provision of EIA for projects to be established in coastal areas. Among others, important issues to consider are: the impacts from building a number of small plants versus a few larger ones; the potential impacts of short-term projects if they continue to operate in the long term; the potential impacts on socio-economic growth from the additional water supplied by a number of projects; and the environmental effects of additional power production if needed for the operation of desalination plants.

Recommendations for Regulatory Authority

National Environment Authority Over Desalination Projects

National environment authorities should be involved in a desalination project proposal as early as possible and in any case before the decision to build a plant is taken. Desalination proposals should always be considered in the context of the overall coastal water management plan. All opportunities for water conservation and reclamation should in fact be first considered in the area where a desalination plant is planned to be built. Water supply alternatives such as drawing water from an existing aqueduct or reservoir should also be considered. If the desalination plant is considered the only solution, different sites and different desalination technologies should be examined and discussed having in mind that the final objective is to minimize/avoid potential adverse environmental impacts from the future plant.

Accordingly, the national environment authorities may become involved in the process of reviewing permits for desalination plants or related facilities in several ways, under the following provisions:

1) If the proposal includes development in an area of the coastal zone, the development plan in the concerned area should be in line with the overall coastal development plan or national development plan, as appropriate, under which the national environmental authority could issue the necessary permits;

2) The competent national environment authority will review the permit submitted for desalination plants;

3) The competent national environment authority retains permit jurisdiction over any portion of a project that is in state waters, on land up to the mean high tide line, or on lands subject to the public trust. If development is proposed within these areas, a permit will be required;

4) The competent national environment authority reviews a desalination plant proposal for its potential impacts on the coastal zone.

Interagency Task Force

The competent national environment authority should consider establishing and/or participating in an interagency task force to address issues related to desalination. The task force may include agencies such as the coastal development plan commission, if available, the Department of Fisheries, the Department of Water Resources, Regional Water Quality Control Boards, the State Water Resources Control Board, and other local, state, and federal agencies, local governments, and water management agencies, as appropriate.

The interagency task force should establish criteria for determining when a desalination project is appropriate for supplying water, and when alternative water supply options are preferable. National environment authorities should encourage local entities to use all options for water reclamation and conservation.

Information on Effects of Discharges

The national environment authority should encourage research on the marine resources and water quality impacts of discharges from desalination plants.

Permit requirements to be integrated in national permit systems

Specific requirements should be included in the national permit systems for the establishment of seawater desalination plants, such as:

1. An adequate description of the proposed development project including maps, plans, photographs, etc.;
2. Compliance of the site selected and of its vicinities with all relevant national policies as well as sufficient information concerning land use and water management of the area in the vicinity of the site proposed;
3. The description of any feasible alternative or any feasible mitigation measure that would substantially lessen any significant adverse impact that the project development may have on the environment;
4. The proof of the legal right, interest or other entitlement by the owner/manager to use the property exclusively for the proposed development;
5. The owner should submit with the coastal development permit application evidence that the proposed discharges are authorized by the competent national authority;
6. If a permit for disposal of solid waste is required, this permit should also be submitted to the competent national environment authority together with the coastal development permit application;
7. All permits required for a proposed project must be obtained prior to plant operation;
8. The preparation of an E.I.A. study according to UNEP methodology (Regional Seas Reports and Studies No. 122. An Approach to Environmental Impact Assessment for Projects Affecting the Coastal and Marine Environment).

Recommendation for impacts/mitigation measures to be considered by national environment authority

Developments in the coastal zone must conform to the policies and standards of the coastal development plan, if available. The national environment authority reviews projects on a case-by-case basis and considers the environmental benefits and coastal zone impacts of all projects. The following types of potential coastal zone impacts should be considered and addressed for desalination plants:

- Construction
- Energy Use
- Air Quality
- Marine Environment
- Increased Development
- Other Coastal Zone Issues (geologic hazards, navigation, cumulative effects, etc.)

Construction

- **Potential Impacts**

Construction activities could result in the following types of coastal zone impacts: air emissions; disturbance of dune, surf zone, and seafloor ecology; disturbance to seabirds, marine mammals, other land and marine species, and their habitats; disturbance to archaeological and paleontological resources; erosion; interference with public access and recreation; noise; non-point source pollution; and obstruction of views by machinery, piping, or tall structures.

Significant construction impacts may also occur away from the desalination plant site if long pipelines are needed for seawater intake or for distribution of the product water, or if power transmission lines or distribution facilities must be built. Pipeline routes may have adverse impacts on benthic habitats such as surfgrass and rocky tidepools. Streambed or lagoon ecosystems along power transmission line routes would be of particular concern. Any proposed diking, filling, or dredging activities in open coastal waters, wetlands, or estuaries must be in compliance with the Dumping Protocol guidelines.

- **Management of Potential Mitigation Measures**

- Minimize the numbers and lengths of pipelines and power transmission lines;

- Dredged materials disposed according to the Guidelines for the management of dredged materials (MTS No. 136 – Guidelines for the Management of Dredge Materials under the Provision of the Dumping Protocol;

- Site pipeline routes to minimize impacts to sensitive areas;

- Site plants in locations where existing intake or outfall structures may be used or minimize the size of new seawater intake and outfall structures; and

- Incorporate mitigation measures commonly required for construction activities (e.g., construction schedules that minimize impacts on public access and recreation, visual screening, noise buffers, siting away from high resource areas, limited construction zones and corridors, etc.).

Energy Use

- **Potential Impacts**

Desalination plants require significant amounts of energy for their operation. For example, a desalination plant could use about 26 mWh of electricity per cubic meter of water produced before the plant shut down operations. In most cases, reverse osmosis (RO) plants are less energy intensive than distillation plants.

When the national legislation requires new developments to minimize energy consumption, as a consequence the national environment authority will review desalination plant proposals to determine if a project incorporates means to conserve energy or reduce energy use. The national environment authority should also consider the secondary impacts resulting from the increase in power production needed for the desalination plants. These impacts include higher levels of air emissions, increased entrainment and impingement of fish from intake of cooling water, higher levels of cooling water discharges to the Mediterranean sea, and effects from additional transportation of oil and gas.

- **Cogeneration**

Cogeneration is a process in which exhaust steam from electricity-generating plants is used for another purpose. If a desalination plant uses cogeneration to supply part of its energy needs, the plant could reduce both its demand for power and the associated environmental impacts of power generation.

For example, a distillation plant can use the heat in a power plant's exhaust steam to evaporate feedwater. A cogeneration power plant that operates with a distillation plant must however be specially designed for that purpose. A distillation plant that is dependent on a power plant's exhaust steam for its operation would not be able to operate when the power plant is not operating.

An RO plant can also use exhaust steam from a power plant to heat feedwater slightly. In this application, the RO plant depends on electricity to power its high pressure pumps; the thermal heat from the power plant improves the production of the desalination process but does not power the plant. Therefore, RO plants can operate with or without the heat from the power plant, and the power plant does not have to be specially designed to fit with the desalination plant. Cogeneration can also be used in RO plants by using exhaust steam in a steam turbine to power the pressure pumps.

A third option for cogeneration is in a hybrid plant that uses both RO and distillation (e.g., MSF) technologies. Existing power stations can and have been "retrofitted" in the evaporators and RO units to achieve a hybrid plant, thus eliminating the need to construct a new desalination facility. The MSF plant draws waste steam from a thermal power station and uses the energy in the steam to preheat seawater which is then distilled in the MSF unit. The RO unit uses electricity from the power station and operates during periods of reduced power demand, thus optimizing the overall efficiency of the entire operation. Advantages of the hybrid design include: reduced energy costs (the distillation portion would have energy savings from cogeneration, while the RO portion could use electricity from the grid to produce water when the power plant is not in operation) and reduced capital and operating costs from reuse of cooling water, feedwater or steam.

Although distillation plants usually have higher overall energy requirements than RO plants, the potential energy savings from cogeneration are greater for distillation plants. According to one estimate, use of cogeneration at an RO plant that produces 60 million m^3/yr could reduce

electricity consumption by about 7%. According to another estimate, for an RO plant that produces 200 to 240 million m^3/yr of water and that uses the exhaust steam from a power plant to heat the feedwater 75°C, the electricity demand could be reduced 10 to 15%; for a distillation plant of the same capacity that uses cogeneration, the reduction in demand for additional energy sources could be 20 to 25%.

One option being considered is to design and build a new power plant to operate in conjunction with a desalination facility. A power plant designed specifically for cogeneration with a desalination plant could produce lower air emissions than existing power plants if the new plant is fired with natural gas and uses the latest air emission control technologies. However, construction and operation of a new power plant could have a number of adverse impacts including air emissions, impacts on marine resources, degradation of visual and recreational opportunities, disturbance of sensitive habitat areas, and increased growth in coastal communities.

- **Other Options for Saving Energy**

One method for reducing energy use in all types of desalination plants is by employing energy recovery. In the case of distillation, heat in the brine and fresh water leaving the plant is used to preheat the feedwater. In RO, energy is recovered by converting hydraulic pressure in the brine to electricity or by transferring this energy to the feedwater.

Solar energy could also be used to heat the water for a small distillation plant. Solar energy is expensive compared to other desalination technologies and may require a larger area for the solar energy gathering and conversion devices; however, this technology would not produce toxic air emissions and would not consume exhaustible resources.

- **Potential Mitigation Measures**

- Preference for desalination technologies and plant designs that reduce energy consumption;

- Use of renewable energy resources, when feasible; and

- Siting of the proposed plants near to power plants capable of cogeneration.

Air Quality

- **Potential Impacts**

In general, desalination plant air emissions consist only of discharges of nitrogen and oxygen from distillation plants that use deaeration processes to reduce corrosion, discharge of the air ejector system (thermal plants), or discharge of the degassifier (RO plants).

The production of energy for use in desalination plants, however, will increase air emissions of Nox, Sox, soot, etc. In addition, substantial increases in air emissions could occur if a new power plant or cogeneration facility is built for a desalination project.

- **Potential Mitigation Measures**

- Compliance with local national Air Pollution Control standards;

- Preference for reduced energy use, as discussed above; and

- Use of alternative energy sources to minimize air emissions.

Marine Environment

- **Marine Resource Impacts from Desalination Waste Discharges**

The constituents of water discharged from desalination plants depend in part on: the desalination technology used; the quality of the intake water; the quality of water produced; and the pretreatment, cleaning, and RO membrane storage methods used.

All desalination plants use chlorine or other biocides, which are hazardous to marine resources, to clean pipes and other equipment and sometimes to pretreat the feedwater. As an example, the U.S. discharges control does not permit chlorine or other biocides to be discharged directly into the sea. Consequently, these chemicals would have to be neutralized before discharge.

Alternative treatment processes and technologies that eliminate the need for biocides can also be used. For example, ultraviolet light may be used instead of biocides to remove biological organisms. Ultraviolet light is more expensive than biocides but is an effective method. Similarly, the disc tube RO technology does not require use of pretreatment chemicals to remove particles and organisms. This technology, unlike the more common spiral wound RO technology, does not have a mesh net between layers of the RO membranes (the net catches particles and biological organisms and can clog the membranes). The disc tube technology, however, is more expensive than the spiral wound technology and, according to one source, is unproven on seawater desalination. The need for pretreatment chemicals and processes can also be eliminated or reduced substantially if feedwater is taken in from beach wells or infiltration galleries, which serve as natural filters. (An infiltration gallery has perforated pipes arranged in a radial pattern in the saturated sand onshore, and water in the sand seeps into the perforated pipes.).

Some RO plants use a coagulant (usually ferric chloride), as part of the pretreatment process to cause particles in feedwater to form larger masses that can be more easily removed with filters before the water passes through to the RO membranes. The pretreatment filters are backwashed with filtered seawater every few days, producing a sludge that contains filter coagulant chemicals. Options for disposal of coagulants, particles and sludge removed from the filters include discharge with the brine, transport to a landfill, or a combination thereof. A desalination plant would have to include a process for removal of the particles if they are to be discharged with the sludge. Ferric chloride is not toxic but may cause a discoloration of the receiving water if discharged.

Desalination plants often use anti-scalants to remove scales that form on the plant's interior. Most plants use a polyacrylic acid as an anti-scalant, which is not hazardous to marine resources. MSF distillation plants may use a small quantity, about 0.1 milligrams for each liter of water, of an antifoaming agent (similar to cooking oil) to reduce the foam produced when the water boils.

In RO plants, cleaning and storage of the membranes can produce potentially hazardous wastes. The membranes must be cleaned at intervals from three to six months depending on feedwater quality and plant operation. The membrane cleaning formulations are usually dilute alkaline or acid aqueous solutions. In addition, a chemical preservation solution (usually sodium bisulfite) must be used if the membranes are stored while a plant is shut down. These chemicals should be treated before discharge to the Mediterranean sea to remove any potential toxicity.

In general, discharges from desalination plants may have the following types of potentially adverse constituents and qualities:

- Salt concentrations above those of receiving waters (seawater salt concentration is about 35,000 ppm; desalination plants discharge brine with 46,000 to 80,000 ppm). Salt concentrations may be reduced by mixing desalination plant discharges with other discharges, such as wastewater;

- Temperatures above those of receiving waters (about 10°C increase at the point of discharge) for discharges from distillation plants;

- Turbidity levels above those of receiving waters;

- Oxygen levels below those of receiving waters from deaeration to reduce corrosion (distillation plants only);

- Chemicals from pretreatment of the feedwater (these may include biocides, sulfur dioxide, coagulants (e.g., ferric chloride), carbon dioxide, polyelectrolytes, anti-scalants (e.g., polyacrylic acid), sodium bisulfite, antifoam agents, and polymers);

- Chemicals used in flushing the pipelines and cleaning the membranes in RO plants (these may include sodium compounds, hydrochloric acid, citric acid, alkalines, polyphosphate, biocides, copper sulfate, and acrolein);

- Chemicals used to preserve the RO membranes (e.g., propylene glycol, glycerine, or sodium bisulfite);

- Organics and metals that are contained in the feedwater and concentrated in the desalination process; and

- Metals that are picked up by the brine in contact with plant components and pipelines.

Concern over the potential adverse effects to marine resources of desalination plant discharges is tempered by the following factors: 1) the total volume of brine being released; 2) the constituents of the brine discharge; and 3) the amount of dilution prior to release. For example, the potential for environmental damage from small amounts of brine discharge (less than 1 MGD) may differ considerably from the potential impacts associated with discharges greater than this amount. Discharge of concentrated brine in large amounts requires more careful consideration of potential environmental impacts than do smaller brine discharge volumes.

The constituents of discharges of particular concern for marine organisms include biocides, high metal concentrations, and low oxygen levels. Not all desalination plant discharges contain these constituents; however, where detected, these constituents should be removed or neutralized to acceptable levels before discharge in accordance with national permit requirements for compliance to discharge standards.

The high salt concentration of the discharge water and fluctuations in salinity levels may kill organisms near the outfall that cannot tolerate either high salinity levels or fluctuations in the levels (similarly, if a temporary desalination plant is shut down, the organisms that have become accustomed to high salinity levels and/or salinity fluctuations may be killed). In addition, discharges from desalination plants will be more dense than seawater and could sink to the bottom, potentially causing adverse impacts to benthic communities. These effects may be significantly reduced if desalination plant discharges are combined with sewage treatment plant discharges (which are less dense than seawater) or are diluted by mixing with power plant cooling water discharges. The metals may become concentrated in the upper few micrometers of the sea (the microlayer), which would be toxic to fish eggs, plankton, and larvae that are located there. Toxic constituents of the plume could be driven by wind or currents to become concentrated in the intertidal zone.

Discharge of brine water with high salt concentration, particularly if combined with sewage effluent, may also cause sewage contaminants and other particulates to aggregate in particles of different sizes than they would otherwise. This effect influences rates of sedimentation, and is highly important for determining the well-being of benthic organisms that may be buried or burdened by an increase in deposition of unstable and/or finely suspended materials. If the particles are smaller and stay in suspension, they could interfere with transference of light in the Mediterranean sea, which would diminish the productivity of kelp beds and phytoplankton. In addition, redistribution of trace metals (e.g., iron, nitrogen, and phosphorus) could change the phytoplankton community to one that is unappetizing to fish and may also be toxic. Larval fish that feed on the phytoplankton could be forced beyond nearshore waters, where they may not survive.

Changes in salinity and/or temperature from the brine discharges may also affect migration patterns of fish along the coast. If some fish species sense a change in salinity or temperature, they may avoid the area of the plume and move further offshore. As a result, the fish would be forced to swim a longer distance, they would leave the areas of highest food concentrations, and they would have increased exposure to predators. The potential impacts of this nature are uncertain because of limited knowledge about fish migration along the coast and uncertainty about how large the plume would have to be to cause this effect.

- **Waste Discharge Methods**

The brine from desalination plants can be discharged directly into the Mediterranean sea or combined with power plant cooling water or post-treatment sewage plant discharges. Mixing the discharges with power plant cooling water would most likely be desirable, because the brine solution discharged would be considerably less concentrated. Mixing with sewage treatment discharges may also be preferable to direct discharge to the Mediterranean sea. Brine discharge from desalination plants is more dense than seawater and could remain or fall to the sea bottom, depending on the outfall location. Treated sewage effluent has a relatively low level of total dissolved solids, and blended brine/wastewater effluent has the potential to be closer to ambient sea concentrations, so dispersion may be enhanced beyond a brine-only discharge. The addition of brine discharge to wastewater effluent reduces the biological oxygen demand (BOD) of the sewage effluent and has the potential to reduce the temperature of the sewage effluent. On the other hand, blending the brine discharge with sewage discharges may have some undesirable side-effects, which are discussed below under Marine Resource Impacts.

Difficulties in enforcement may arise if desalination wastes are mixed with other waste streams. If the recipient of the desalination waste stream is the only party responsible for compliance with the regulatory requirements, this discharger would have to request the desalination plant operator to make changes if problems with compliance develop. If a

proposed desalination plant incorporates combined discharges, the project description must identify the party or parties responsible for meeting the discharge requirements in order to avoid enforcement problems.

- **Marine Resource Impacts from Desalination Plant Intake**

Intake of water directly from the Mediterranean sea usually results in loss of marine species as a result of impingement and entrainment. Impingement is when species collide with screens at the intake; entrainment occurs when species are taken into the plant with the feedwater and killed during plant processes. The intake of feedwater can also affect marine resources by altering natural currents in the area of the intake structure.

The use of beach wells or infiltration galleries eliminates these impacts. Beach wells should only be used in areas where the impact on aquifers has been studied and saltwater intrusion of freshwater aquifers will not occur. Infiltration galleries are constructed by digging into sand on the beach, which could result in the disturbance of sand dunes.

- **Potential Mitigation Measures to Reduce Marine Resource Impacts**

- Intake and outfall siting and design to avoid sensitive locations;

- Low flow velocities at intake channels and through intake structures to minimize entrainment and impingement of marine species and to reduce the need for pretreatment;

- Intake design to reduce the potential for entrainment and impingement (e.g., screens at the intake to reduce entrainment);

- Use of onshore intake wells or infiltration galleries to eliminate entrainment of marine species;

- Outfall siting and design to ensure an adequate mixing rate and dilution volume to minimize adverse impacts;

- Outfalls to the open Mediterranean sea, not to estuaries or other areas with limited water circulation;

- Use of pretreatment techniques that minimize or eliminate the need for hazardous chemicals;

- Removal of hazardous constituents in the brine waste stream prior to discharge;

- Evaluation of whether landfill disposal would have more or less impacts than Mediterranean sea disposal;

- Mixing with sewage treatment plant or power plant cooling water discharges (when mixing of discharge streams is intended, ensure that a desirable proportion of each discharge is maintained to enhance dilution);

- Use of pipes that minimize the corrosion of hazardous substances (polyethylene or titanium is preferable to copper nickel); and

- Timing of operations to minimize impacts (e.g., intermittent operations to minimize discharges at times during the lunar month when fish migrations are highest; or operation

only during the winter season when the Mediterranean sea is more turbulent, and discharges would be more readily diluted).

Other Coastal Zone Issues

- **Impacts**

The following potential coastal zone impacts should be considered in evaluating proposals for desalination plants:

- Impacts to the marine environment from accidental discharges of hazardous materials;
- Impacts to commercial fishing and navigation during construction of intakes and outfalls and during operation;
- Interference with public access and recreation from pipelines, wells or other structures;
- Visual impacts - towers for most distillation plants will be 9 to 14 meter high; RO plants are usually not more than 4.5 to 6 meter high;
- Impacts resulting from geologic hazards and seismic activity;
- Noise from pumps during operation;
- Impacts on the desalination process from pollution near the intake pipes (e.g., discharges from other sources, oil spills, etc.);
- Use of landfill disposal space for solid waste disposal;
- Impacts from increased chloride concentration - RO product water may have higher levels of chlorides than other water sources (using product water with high levels of chloride for irrigation may result in more water use and adverse impacts on soils; chloride levels can be reduced by employing more passes [RO plants] or by using a different process [e.g., MSF, MED, VC]); and
- Cumulative impacts of the desalination plants in the coastal zone.

- **Potential Mitigation Measures to Minimize the Impacts Listed Above**

- Quality control procedures and personnel training to avoid accidents; Secondary containment for chemical feed lines and provisions for leak detection;
- Notification of commercial fishing interests and the related authorities prior to construction; Placement of navigational buoys on any new intakes and outfalls;
- Provisions for public access and timing of construction to avoid peak recreational periods;
- Architectural design and natural buffers to reduce visual impacts;
- Preliminary siting studies of potential geologic hazards conducted by geologists or engineering geologists;
- Equipment enclosures to reduce noise levels;

- Siting to avoid pollutants near the intake; and
- Recycling or reuse of solid wastes.

Recommendations for monitoring programmes

Monitoring programmes to prevent, assess and minimize the adverse impacts possibly resulting from sea water desalination projects should be established separately or as an integrated part of National monitoring programmes. Two types of monitoring activities are recommended:

- **Pre-Operational Monitoring and Baseline Information on Marine Resources**

The following types of pre-operational baseline information would be needed by the national environment authority in order to evaluate the effects of desalination plant discharges on the marine resources:

- Studies of the effects of discharges from a pilot plant built where a final plant will be located;
- Measurements of dispersion rates to determine how readily brine will disperse in the Mediterranean sea;
- Laboratory studies to determine the effect on particle size of mixing brine and sewage water;
- Laboratory studies to determine the dispersion of metals;
- Tracer studies using small quantities of non-radioactive isotopes of metals to determine the quantity of metals that end up in the Mediterranean sea microlayer;
- An inventory of marine organisms in the area of the outfall; and
- A long-term inventory of marine organisms in the microlayer.

- **Post-Operational Monitoring of Marine Resources**

- Secchi Disk Depth Test to measure how much light is penetrating the water column (to determine whether there may be an impact on the benthos);
- Measurements of impacts on habitat in the microlayer;
- Measurements of impacts on fish in the water column;
- Plume trajectory evaluation of depth, temperature, salinity, and density;
- Nontoxic dye tests to measure dilution;
- Sampling of sediments; and
- Measurements of salinity at various offshore sampling locations.